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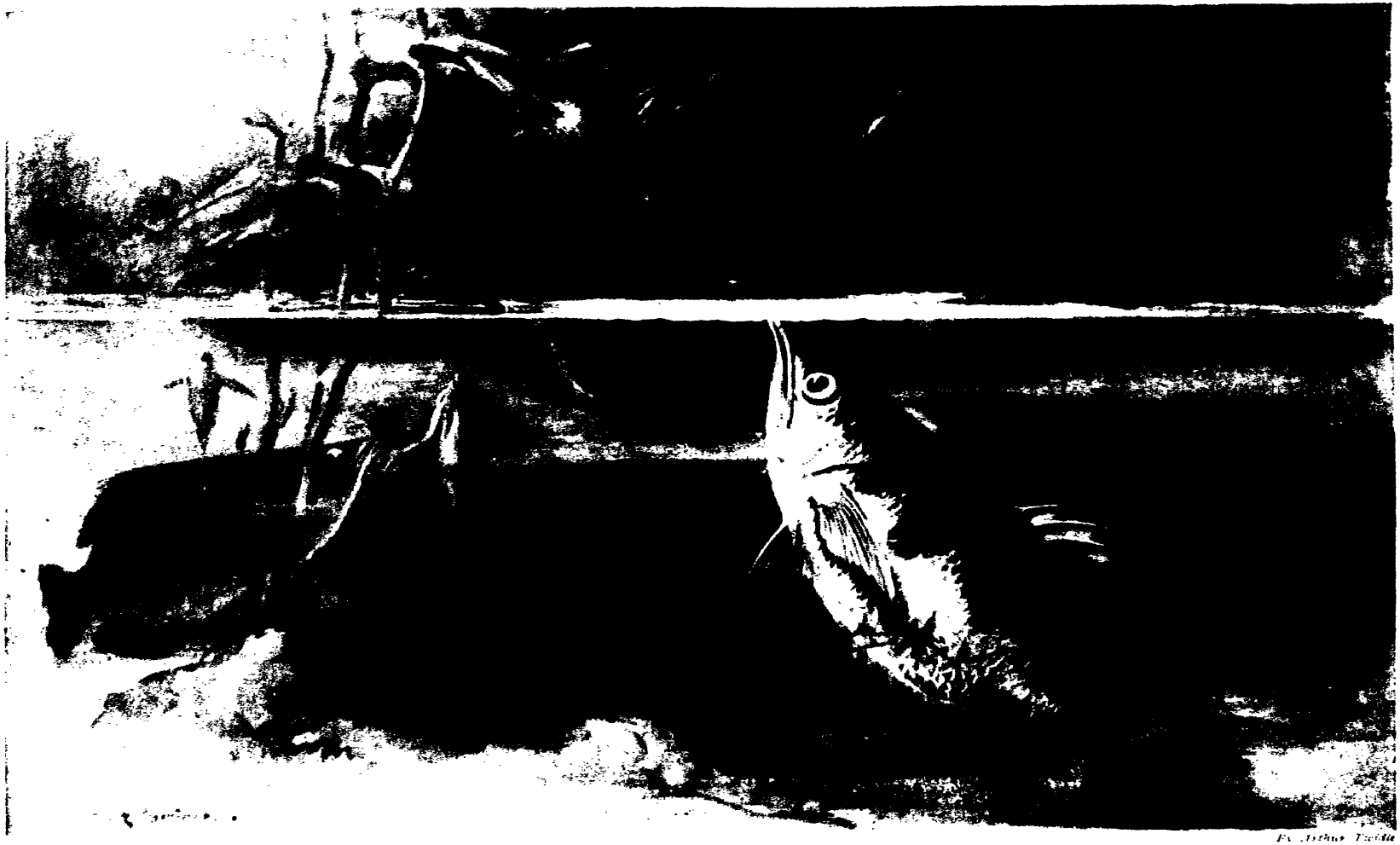
WONDERS OF LAND AND SEA



A Sportsman Among Fishes

The Archer is an expert gunner. Although there may be worms in abundance on the river bottom, it prefers to shoot down flies and other small creatures from the bank, by means of a series of well-aimed "bullets" of water, which it ejects in rapid succession

WONDERS OF LAND AND SEA

EDITED BY

GRAEME WILLIAMS, F.R.G.S.

Fellow of the Royal Historical, the Geological, and the Zoological Societies

With an Introduction by

SIR H. H. JOHNSTON, G.C.M.G., K.C.B.

And Contributions by Many other Eminent Specialists

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The Archer Fish

An Account of a Remarkable Finny Sportsman, included in this section, like other River Dwellers, to distinguish between them and the Sea-folk

By GRAEME WILLIAMS, F.R.G.S., F.Z.S.

ARE there any fish that share with man the sporting instinct? In ancient times, when much more remarkable statements found ready credence, it was asserted that certain fish would ignore more easily-won edibles in favour of insects on the bank, which they would skilfully bring down to the water's surface by means of a well-aimed shot.

Since scientists began sternly to demand proof of alleged facts, many tall stories have been discredited, and this among them. Nevertheless, it has been established recently, apparently beyond dispute, that "sporting" fishes really do exist, of which the Archer is king. I will place before the reader the evidence of credible witnesses, including that of the Russian savant, Zolotnitsky.

Credible Witnesses

"We have," says Sir Charles Bell, "a curious instance of the precision of the eye and of the adaptation of muscular action, in the beaked chætodon, a fish which inhabits the Indian rivers and lives on the smaller aquatic flies. When it observes a fly alighted on a twig, or flying over it—for it can shoot them on the wing—it darts a drop of water with so steady an aim as to bring the fly down into the water, when it falls an easy prey. It will hit a fly at the distance of from three to six feet. Another fish, of the same order, the Zeus, has the power of forming its mouth into a tube and squirting at flies, so as to encumber their wings and bring them to the surface of the water. In these instances a difficulty will readily occur to the reader. How does the fish judge of position, since the rays of light are refracted at the surface of the water? Does instinct enable it to do this, or is it by experience?"

Nearly a century ago travellers reported having seen specimens of the Jaculator fish in Java. They were exhibited by a native chief, who kept them in a pond, in the middle of which was placed a short branch. For the amusement of his visitors the chief instructed attendants to place living beetles on it.

"When the slaves had placed the beetles, the fish came out of their holes and swam round the pond," says one account. "One of them came to the surface of the water, resting there, and, after steadily fixing its eyes for some time on a beetle, it discharged from its mouth a small quantity of water with such force and precision of aim as to strike it off the twig into the water, and in an instant swallowed it. After this another fish came and performed a similar feat, and so the sport continued until they had secured all the beetles. If a fish failed in bringing down its prey at the first shot, it swam round the pond till it came opposite the same object, and fired again. In one instance a fish returned three times to the attack before it secured its prey, but in general the fish seemed very expert gunners, bringing down the beetle at the first shot."

Expert Gunners

Before this date a description of this interesting fish was communicated to the Royal Society of London by Governor

The Archer Fish

Hommel of Batavia (*Philosophical Transactions* of 1767).

"When the Jaculator fish intends to catch fly or any other insect which he sees at a distance," declared the Governor of Batavia, "it approaches very slowly and cautiously, and goes as much as possible perpendicularly under the object; then, the body being put in an oblique situation, and the mouth and eyes being near the surface of the water, the Jaculator stays a moment quite immovable, having its eyes directly fixed on the insect, and then begins to shoot, without ever showing its mouth above the surface of the water, out of which the single drop, shot at the object, seems to rise. With the closest attention, I never could see any part of the mouth out of the water, though I have very often seen the Jaculator fish shoot a great many drops one after another without leaving its place and fixed situation."

An Early Account

In spite of the position and integrity of this witness, he was very generally credited with the imagination of another Baron Münchausen until a recent date, when a Russian savant, Mons. N. Zolotnitsky, published an account of the fish. A summary of his article on the Archer fish, which he observed for a long time in his own aquarium, appears in the Smithsonian Miscellaneous Collection, Vol. 52.

"They frequently swim backwards as well as forwards," says Zolotnitsky. "This habit of swimming backwards is very curious and quite customary; indeed, they often swim in this manner for several minutes at a time. They reconnoitre a possible prey, and back from it until they secure a good position for observation and attack.

"The action of the eyes deserves special notice. They can be moved in almost every direction—to the left, to the right, upwards, and backwards—backwards so that the fish can see everything that goes on behind. Their vision is also very penetrating; they can see small objects at a great distance, and drench them with astonishing correctness of aim. But the eyes cannot be turned downwards, and, consequently, when the fish would see what is below, it plunges forward, head foremost. It rarely, indeed, sees what is at the bottom, and although worms may be there in abundance, it finds them only when hunger impels it to search for them there. And it is not alone the mobility of the eyes which engages attention; instead of the expressionless stare which is characteristic of fishes generally, the Archer's eyes sparkle with intelligence. Especially when the fish becomes sick or dying is the expression manifested; then it looks at you as if it would implore your attention and would like to speak. The case of one of Zolotnitsky's fishes, which was dying, produced on him such a painful impression that he could never forget it."

It was not surprising, perhaps, that Zolotnitsky's tender heart was penetrated with emotion on seeing one of his tame fish suffer, for his clever pets, imported from Singapore, "were so tame that they would approach the hand containing flies and shoot them off into the water."

Amazing Facts

It is impossible in the amount of space available here to quote one half the amazing facts relative to the Archer fish detailed in Mr. Theodore Gill's summary of Zolotnitsky's paper. Apparently there are few limits to its ingenuity. This finny tribe certainly does not seem to be less greedy than its fellows. It appears that the less expert gunners, finding that their clumsy efforts merely resulted in driving insects away from the aquarium, desisted in favour of the adepts of the family. When the latter exercised their skill, the other fish waited in readiness to snap up the spoil as it fell into the tank, before the successful sportsman could secure it.

The Adder, or Viper, Prepared to Attack

Poison Fangs

Their Real Nature and How the Serpents Got Them

By CLAUDE E. BENSON

IN earth's early ages the average serpent combined with the somewhat problematical wisdom attributed to it the harmlessness, almost literally, of the dove. Indeed, it is difficult to imagine a much more inefficient creature than the innocuous colubrine of to-day. Even the big rat snakes, though they can, and do, bite hard, are very poorly equipped for the struggle for existence, and the lesser members of their family are miserably furnished. As blind as a bat—except immediately after sloughing its skin—as deaf as a post, without power of taste and quite probably without power of smell, with a skeleton so delicately constructed that the tap of a child's cane will break its back, the wonder is that the innocuous colubrine survives.

It not only survives, however, but flourishes. The probable explanation is that it is mistaken for something else. Generally speaking, man and beast assume, on sight, that a serpent is venomous. At any rate, neither man nor beast takes a risk on the hypothesis that it is not. Sometimes the harmless snake encourages this belief. The little *Dasypeltis* of the Cape pretends, as occasion demands, to be a Cape viper, which it nearly resembles in appearance; and in India there is a little serpent with a long name that sets up a hood like a cobra for the purpose of scaring away possible enemies. This device, however, is not always an unqualified success, as man is apt to mistake it for what it is pretending to be, and to knock it on the head accordingly.

There was a time when all venomous snakes were as harmless as their near relative the innocuous colubrine. In fact, they come from the same parent stock. How is it that this feeble, unaggressive, defenceless creature has become the most dreaded of "all the beasts of the field"?

Poison Fangs

In spite of its many physical disabilities, the harmless serpent is provided with a respectable armament of teeth. There are a row on each side of the lower jaw, a row on each side of the upper jaw, and an additional row on each side of the palate, making, in all, six rows of strong, sharp, recurved teeth. A creature entangled in this rat-trap arrangement has little chance of escaping, a position complicated by the fact that the snake would have extreme difficulty in releasing its capture, if it wanted to ever so badly.

Now, if the prey happen to be a helpless frog, for example, such a meal is simply and quietly swallowed alive. A serpent's head, it may be said, with the exception of the skull, takes all to pieces. The lower jaws come away from the head at the base, and from each other at the chin, and the snake just pushes first one forward and then another, taking alternately fresh holds, until its food is safely stowed in its gullet. This answers very well in the case of the frog. True, I have known a frog eat a snake, and a fair-sized snake at that, but that was a variation from the normal. The frog was, in fact, abnormal, an exceptionally fine specimen. If, however, through mistaken identity or defective eyesight, the snake happens to seize a weasel or a rat, or some such animal, the intended victim may secure its release by the simple process of gnawing the captor's head off.

Now see how evolution has enabled certain branches of the tribe to meet this difficulty. Some thousands of years ago, apparently, the cleverer colubrines set to work to safeguard themselves against the possibility of such dangerous mistakes. A portion of the salivary gland was accordingly modified, and a certain inexplicable concentration took place which resulted in the receptacle being filled with venom. At the same time a groove was formed in the base of sundry of the larger teeth to serve as a channel for the transmission of the poison.

Photo. W. S. Berridge, F.Z.S.

Indian Cobras

When attacking, the cobra raises its head and strikes forward

So far, so good, but with the ammunition stowed away at the back of the head and the weapon in the mouth, under the eye, the snake was no better off. A tube was, therefore, run from the poison magazine out on to the gum, just above the base of the fangs, where it terminated in a small papilla. The theory that the poison duct is produced into the fang itself is incorrect, in fact, impossible.

The fang, it must be understood, is not socketed into the upper jawbone, as is the case with our teeth, but merely attached to the gum, and is easily displaced. The wound thus caused on the gum cicatrises, and the consequent contraction draws forward a reserve fang (of which there is an illimitable supply) into its place as functional fang in the front of the jaw. It is quite evident that if the poison duct were produced into the fang it would, during the process of substitution, be left hanging out, and would dry and shrivel up into uselessness.

Now, as I shall presently show, the

venom is injected with great force. How comes it, then, that it is not all dissipated, but finds its way into the wounds caused by the fangs? First of all, there is a strong sphincter muscle, close to the fore extremity of the poison duct, which prevents any involuntary escape of the venom. Secondly, the venom is directed downwards by the fang-sheath, a prolongation of the gum which covers the fangs when quiescent, but which, when the snake strikes, is wrinkled up along the upper lip, very much after the fashion of the upper lip of a man when he sneers. Nevertheless, in spite of this apparatus, a portion of venom always does escape when the snake strikes, and is found scattered round the outside of the wound.

As I have said, the venom is discharged with great force. Round the venom gland is wound a powerful muscle which passes round the back of the mouth, and is inserted on the lower jaw. Thus, albeit the snake can open and shut its mouth without discharging its venom, it cannot discharge its venom effectively without closing, indeed snapping, its jaws. To this fact many men and

A snake, in addition to its natural purblindness, is a bad shot, and a wretched judge of distance. If a cobra struck at the back of one's hand, and you moved your hand a couple of inches back, or tilted it away from the stroke, the chances are that the fangs would not penetrate. I have often tried this experiment, substituting

The Most Deadly of Poison Snakes

The Mamba is here shown with distended jaws to exhibit its two huge pairs of poison fangs in the upper jaw

a bit of paper in a cleft stick for the back of my hand. I shall have something more to say about the attack of venomous snakes later on.

Here, then, we have the ancestral innocuous colubrine, no longer innocuous, but with poison fangs either at the front of his mouth and a fair complement of solid teeth behind, or with poison fangs at the back of his mouth, with a sufficiency of solid teeth in front. This last arrangement seems foolish, inasmuch as the prey had to be hitched back by the solid teeth, right away to the base of the jaws before the poison fangs could take effect. It is highly improbable that a rat or weasel would submit to such a process without vigorous protest, and it is not unreasonable to suggest that this fact, being drilled into the brains of the back-fanged snakes by such uncomfortable captures, led to the discarding of the front solid teeth, and the evolution of the formidable family of vipers.

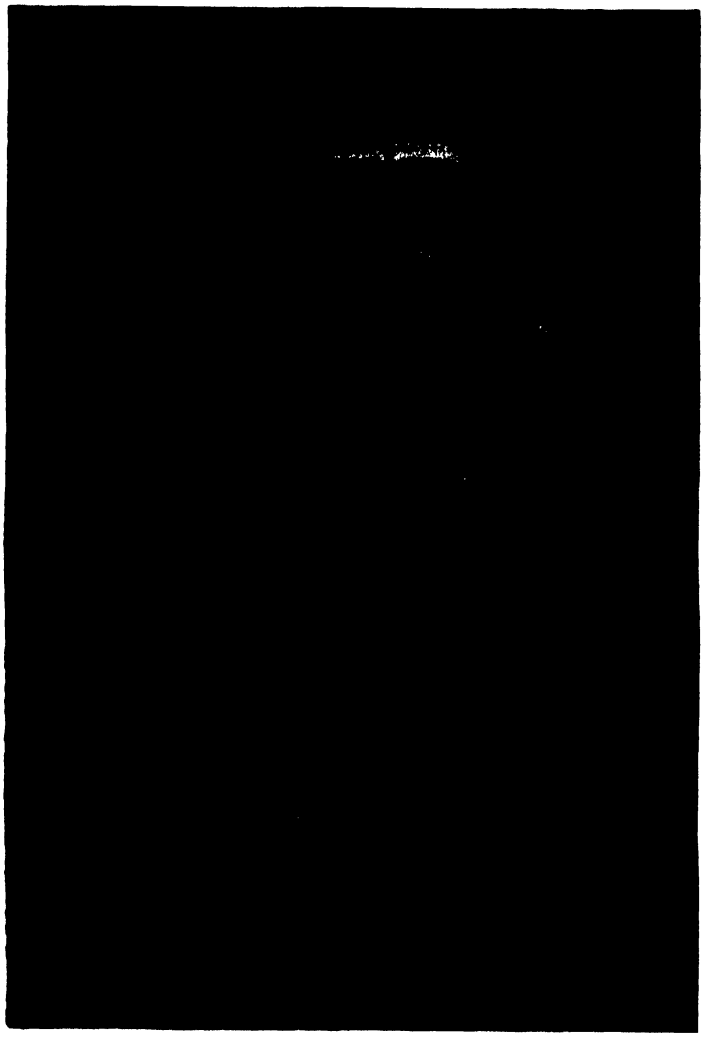


Photo: International Press Photo.

Skeleton of a Rattlesnake or Pit Viper

To show the marvellous bony framework. (At the base, another American snake, the Mocassin)

Meanwhile front-fanged snakes were proceeding on lines even more vicious. Armed as they were, they could both paralyse and hold their victim. Later, the wicked thought occurred: "Why not incapacitate him out of hand without the trouble of having to hold him?" The solid back teeth were accordingly discarded and the size of the poison fang increased until, in such brutes as the cobra, only one or two very effete solid teeth remain. They are placed behind a pair of very large poison fangs, on each side of the mouth, whilst in the most highly specialised of the group, e.g., the coral snake and the mamba, no solid teeth remain.

The evolution in this respect, the gradual discarding of the solid teeth, and the increase in size of the poison fangs, can be readily traced throughout almost every gradation in the poisonous colubrines. In the vipers, one passes at once from the back-fanged snakes, with solid teeth in front of the fangs, to the viper, with its shrunken jawbone bearing poison fangs only. Of course, the viper appears to have

Head of a Puff Adder

Observe the poison fangs in the upper jaw

an upper jaw-bone as long as that of any ordinary innocent snake, but it has not. The upper jawbone has shrunk almost to its base, and lies, a basal wreck, almost at right angles to its initial position, whilst an originally insignificant bone has been lengthened out till it occupies almost the entire length formerly taken up by the upper jawbone.

In the absence of transitional anatomical evidence, the hiatus between the back-fanged snakes and the vipers was so marked as to be considered almost conjectural, till analytical science set the seal on the conclusion by showing that the poison of the back-fanged snake was practically identical with that of vipers, though far less virulent. Incidentally, the poison of the cobras or elapines—miscalled poisonous colubrines, inasmuch as both the poisonous families were, in their innocent state, colubrines—is more deadly; its toxic properties are more active than that of vipers. On the other hand, in horrid compensation, the effects of viper bite are distressingly more severe.

Moreover, the viper comes into being with a fully developed "perforated" fang, exhibiting none of the gradations of development clearly traceable in the elapines. The term "perforated" is a misnomer. I have said that a groove was formed at the base of the tooth. By and by, the groove was extended to the tip, and the edges folded over on each other. Anyone who desires to see exactly what happened has only to take an elm leaf, lay one finger down the stem, and bend the leaves gradually together over his finger. The result will be a sheath with a broad opening at the base and a narrower aperture at the point. In the less specialised cobras, the groove takes the form of a wide slit; in the Indian cobra, the slit has so nearly joined that one can just pass a hair between the edges; in the mamba and coral snake, and in all the vipers, the edges have joined, though the point of juncture is

Photo: W. S. Berridge, F.Z.S.

Skull of an Indian Python

A creature entangled in this rat-trap arrangement of teeth has little chance of

discernible with the naked eye, and can be clearly seen with a magnifying glass.

The method of attack differs in the two families. The cobra raises its head and strikes forward and downward, after the manner of a forward cut with a sword. The viper lies in coil, more or less marked, and, opening its jaws till they are in the same plane, thrusts. The closing of its jaws, in either case, is very essential to the effectual injection of the poison. Of the two, the viper is rather more likely to get home.

Fortunately, most venomous snakes are shy. Some, however, are painfully the reverse. A cobra is not always wholly amiable; a friend of mine has a pair of flannel trousers perforated in the loose flap just over the instep by a bad shot from a cobra, which got irritated at his passing by. A fraction lower, or more to the left, and I should not have that friend to-day. Some Australian snakes are said to be several degrees more vicious, but there is no doubt that the king cobra (the hamadryad), the mamba, and some of the South American pit vipers, will go out of their way for a fight. A mamba killed Colonel Montgomery of the Welsh Regiment, though he was in the doctor's hands within a very few minutes of being struck. It bit clean through putties, the box-cloth of his knickerbockers and his under-garments, and penetrated about an eighth of an inch. A friend of mine, more fortunate, was struck on the thick leather pad on the shoulder of his shooting coat by a mamba that came down a tree to interview him, and retired into space immediately after in company with a charge of shot.

Which of all snakes is most deadly? It is an idle question. Medical science may say that, in the event of a bite, the krait is perhaps the most deadly of all, but the krait is so very small. Let a full-grown, fair-sized viper or cobra in good health get home and close its jaws, and I would not insure the man bitten for sixpence, though the whole College of Surgeons were on the spot.

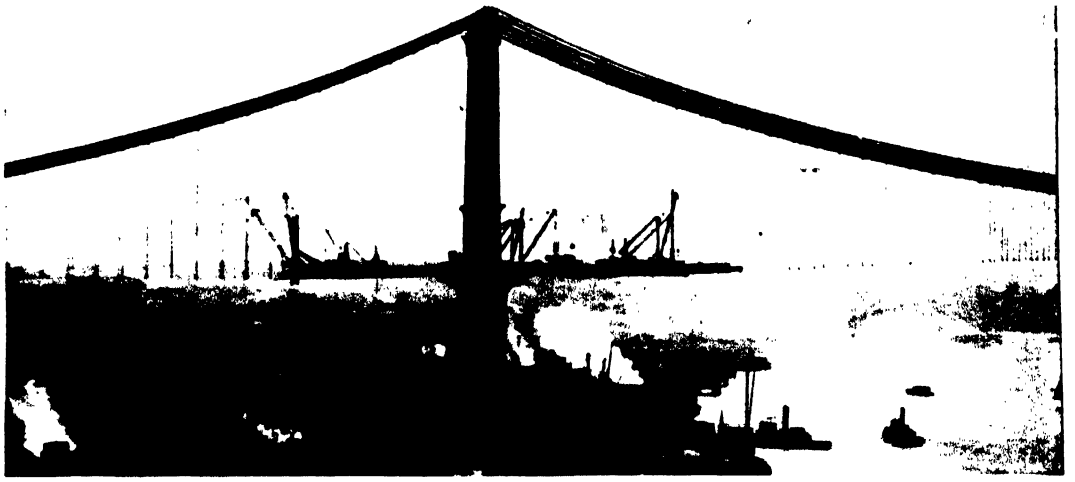
Photo: W. S. Berridge, F.Z.S.

The Egg-swallowing Snake (*Dasypeltis*) of South Africa

This harmless snake protects itself by pretending to be a Cape viper

BRIDGES

By H. J. SHEPSTONE



Building the New Manhattan Bridge, New York

Pathways of Steel Through the Air—Wonders of Modern Engineering. Their Heavy Cost in Men and Money

THE evolution of the bridge is one long heroic struggle on the part of man to throw a roadway over a river or a yawning ravine. Primitive man spanned streams with trunks of fallen trees. Later came the more substantial wooden structures, strong enough to bear a horse and cart. As engineering science developed these were replaced by masonry edifices, capable of carrying a stream of heavy traffic. To-day these are being rapidly superseded by viaducts of steel.

It is over the Hudson River in New York and over the St. Lawrence in Canada that man has gained his greatest victories in spanning wide expanses of water with gigantic steel roadways. It must not be forgotten that Great Britain has many fine examples of the bridge-builders' art; the Royal Albert Bridge at Saltash, the Britannia Bridge over the Menai Strait, and the Forth Bridge, whose span of 1,700 feet has yet to be eclipsed, may be quoted as daring and remarkable bridge-building feats.

The British structures, too, were the first of their kind, and their designers had little to guide them. Now, with our knowledge of steel, and the perfection of innumerable devices for facilitating the task of erection, the feat would not be so difficult.

The Saltash Bridge which spans the Tamar is 2,200 feet long, the two main spans over the river being each 455 feet long. The height of the central pier from its foundation to the top is 240 feet, and the railway track is carried 110 feet above the level of the water. Obtaining the foundations for the pier was a particularly dangerous piece of work. A huge caisson was sunk in midstream, in which, provided with compressed air, the men toiled for two years. In the winter storms the unwieldy cylinder rocked so violently, despite its heavy weights and chains, that

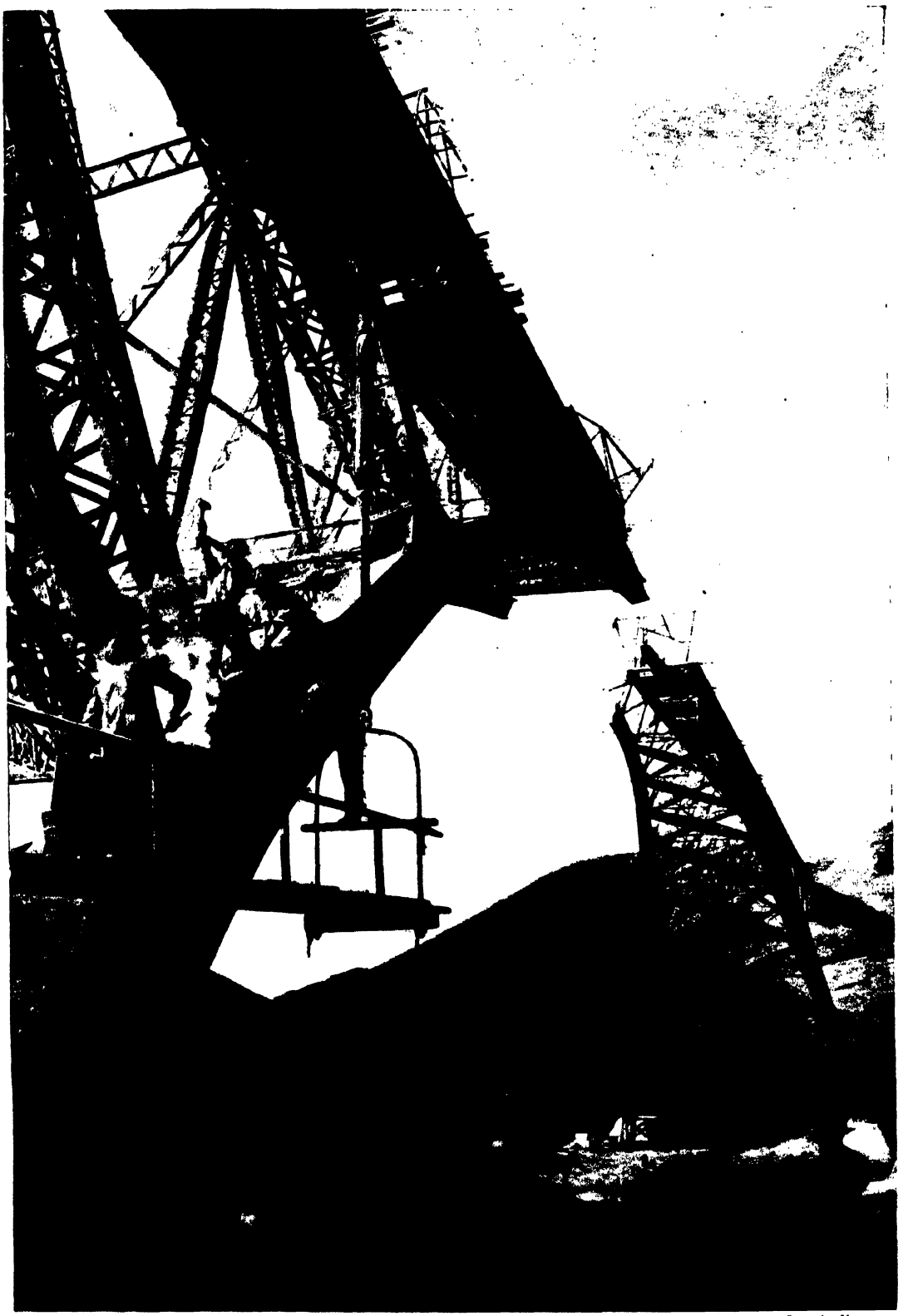
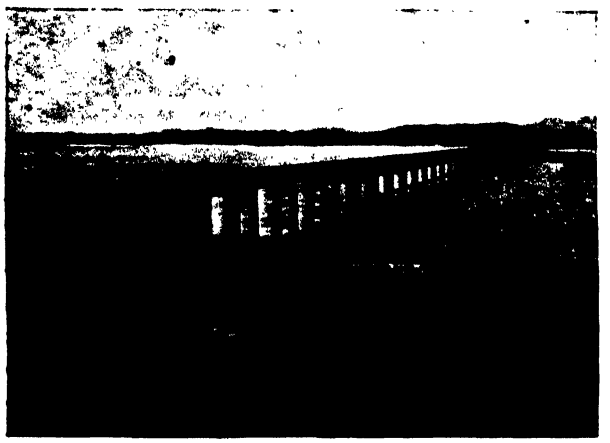


Photo by Vizzavona

Spanning the Rushing Waters

(From the Salon Picture by Henri Marcel Magne)

The first act of the engineers in building the Zambezi Bridge, at the Victoria Falls, was to fire a rocket across the gorge, carrying a cord which served to pull a wire over, which in turn was followed by still stronger material



The Tay Bridge

This bridge, over 2 miles long and rising 77 feet above the sea, was built on 86 pairs of piers, to replace the ill-fated bridge destroyed by a storm on December 28th, 1879

leakages occurred, and it was only by beating hasty retreats that the men escaped drowning. The two gigantic spans were built complete upon the shore and floated out into position, and then gradually raised to the desired height, three feet at a time at each end by means of hydraulic presses.

Over the Menai Strait, which separates the island of Anglesey from Carnarvonshire, we have some magnificent examples of the bridge-builders' skill in the Suspension Bridge, the Britannia Bridge, and, later still, in the bridge at Conway. It is recorded that, when the first chain of the Suspension Bridge was drawn across the strait, half a dozen of the workmen dashed forward, in a mad and perilous race, to see who would be the first to negotiate the stream by the new swaying aerial pathway. Perhaps their feat was not so foolhardy as that of a workman on the great cantilever bridge across the Niagara Gorge, but a narrow gap separated the two cantilever arms, laid a plank across it, walked deliberately to the middle, and stood on his head, kicking his legs about just to show how little he cared for the whirlpool raging two hundred feet below. The last chain of the Menai Suspension Bridge was raised to its position to the strains of the National Anthem, played by a band on a temporary platform on the centre span.

The great steel tubes of the Britannia Bridge, like the girders of the Saltash structure, were built complete on the shore and gradually raised into position. Robert Stephenson, its designer, insisted that the recesses should be filled up with masonry as the tubes rose higher and higher, and on no account would he allow more than a few inches under the ironwork. When one of the tubes had been raised to a height of 30 feet, one of the hydraulic presses broke, and the tube fell a distance of some seven inches on to the packings which had been built up underneath it. So small a fall may appear to the uninitiated to be of slight consequence; but the momentum acquired by the 900 tons of iron grew, even with so small a distance, to such proportions as to crumple up solid castings, weighing tons, as if they had been mere biscuit boxes.

"Thank God," wrote Mr. Clark, the

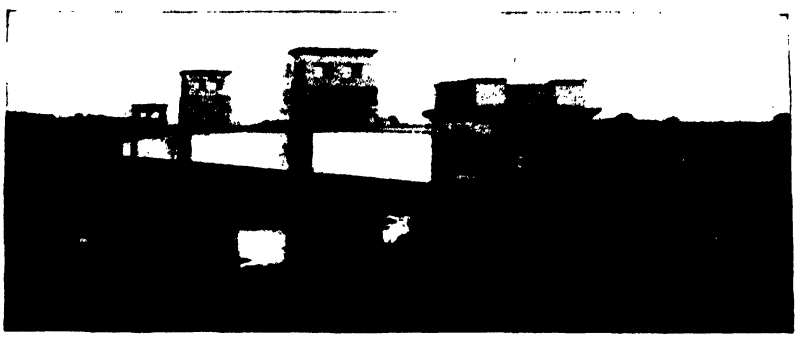
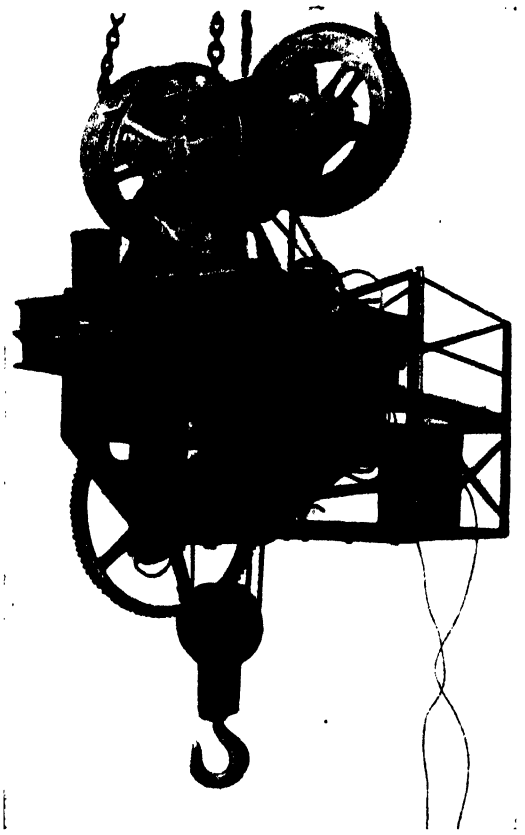


Photo: C. Vaughan

The great steel tubes of which it is composed were built complete on the shore and gradually elevated into position a few inches at a time

engineer-in-chief, to Stephenson, "that you have been so obstinate; for if this accident had occurred with no bed for the end of the tube to fall on, it would have been lying across the bottom of the Strait."

The mightiest bridge in Great Britain is the famous Forth Bridge, which spans the



An Electric Carrier

This carrier, weighing 5 tons and carrying a load of 5 tons, travelled to and fro across the Zambezi Gorge with the materials for the erection of the Victoria Falls Bridge

Firth of Forth, between North Queensferry and South Queensferry, the first big structure to be erected on the cantilever principle, and which to-day still holds the record in length of span. Here it may be explained that cantilever means a bracket. The ordinary balcony of a house is a cantilever of a kind. The principal reason why this form of erection is so popular is because no false-work is needed if that appliance known as the "traveller" is employed. This is a great upright frame mounted on rollers, carrying derricks and other hoisting tackle, and fitted with a long overhanging nose at the front, from which the new pieces of the bridge are hung, while being pinned or riveted together, so as to carry their own weight.

The Forth Bridge, which recently celebrated its majority, has a total length, with its approaches, of 8,295 feet. It contains 50,958 tons of steel, and required 6,500,000 rivets to fasten it together. There are three huge but graceful steel towers, each 345 feet high, from which are built out the great cantilever arms, each 680 feet in length. Sir Benjamin Baker has declared that a battleship could be hung at the end of each cantilever arm without causing the ties at the tops of the tower to part, so strong is the structure. The bridge contains two spans of 1,700 feet, the greatest of all bridge spans. The structure took seven years to build, cost £3,000,000, and demanded a toll of 57 lives.

For the finest and latest examples of the bridge-builders' skill we have to go to New York. Here, in space of a single square mile we have the three greatest suspension bridges in existence—the Brooklyn, the Manhattan, and the Williamsburg bridges, while some three miles above the last-named there now towers Blackwell's Island Bridge. They are rightly regarded as among the wonders of the engineering world. They vary from 6,000 to 7,000 feet in length, with a central span of from 1,400 to 1,500 feet, and carry four tracks for railways, two or more for trams, a couple of roadways for vehicles, and various sidewalks for pedestrians, while the towers reach a height of 800 feet and more above the water, the aerial pathway being some 130 feet above the surface of the river.

The Brooklyn Bridge took thirteen years to build, and cost £8,200,000. It was designed by Mr. John A. Roebling, the builder of the Niagara Falls suspension bridge and

Photo: Illustrations Bureau

Building the Manhattan Bridge, New York

Forty thousand tons of steel and 23,000 miles of wire were used in the erection of this single bridge

Photo: Illustrations Bureau

Building the Blackwell's Island Bridge, New York

In length and weight this recently completed bridge rivals, and in carrying capacity surpasses, the famous Forth Bridge. Its construction cost 67 lives

others. While engaged in the preliminary work he met his death. He was succeeded by his son, Mr. William A. Roebling, who in turn was injured by a fire in one of the caissons and became a permanent invalid. He was removed to a residence on the heights of Brooklyn, where, with indomitable resolution, he watched the details of construction from his window by the aid of a telescope, and, assisted by his wife, directed the progress of the work to its successful completion.

The Collapse of the Quebec Bridge

This photograph of the wreckage was taken from the stone abutment, shoreward. Compare this ruin with the proud structure opposite

It is impossible to point to any large bridge the erection of which has not demanded its toll of human life. The recently completed Blackwell's Island Bridge cost 67 lives; some 70 brave men were killed in the Quebec disaster in 1907, when that partially completed structure suddenly collasped after three years had been spent upon it, and some 15,000 tons of steelwork had been placed and bolted in position.

With its approaches the Brooklyn Bridge is a mile and a furlong in length. There is a central river span of 1,595½ feet from tower to tower, two land spans from towers to anchorages, and the land approach on either side. This aerial roadway is held in place by cables, four in number. They each contain 5,296 steel wires reaching from anchorage to anchorage, on either side of the river, a distance of 3,752 feet. This gives a total of 14,000 miles of wire. Each cable has a diameter of 15¾ inches, and a breaking strain of about 12,000 tons. The roadway is 85 feet wide. The engineers declare that the "natural life" of the bridge is 20,000 years.

After the Brooklyn Bridge came the Williamsburg structure, which was erected in seven years at a cost of £4,000,000. It has a total length of a mile and 1,920 feet, including a main span of 1,600 feet, and two shore spans of 600 feet. The four cables are each 19 inches in diameter, and are built up of 37 strands, each strand containing 208 wires, each 3,020 feet long. Figure this out and we get 19.000 miles of wire, possessing a weight of 5,000 tons.

Photo: F. C. Coleman

At Work on the Ill-fated Quebec Bridge

The men standing on the steel "traveller"—a movable service platform—are engaged in driving the main 12-inch top centre pin of the bridge. They stand at a height of 375 feet above the St. Lawrence River. When this bridge collapsed 70 workmen perished

The towers of this bridge rise 335 feet above the water level, and are built of steel. Somewhat similar in design is the Manhattan Bridge. The wire consumed here totals 23,000 miles, while no less than 40,000 tons of steel were used in the erection of this single aerial pathway.

More wonderful still, from an engineering point of view, is New York's latest structure, Blackwell's Island Bridge. In length and weight it rivals and in carrying capacity also surpasses the famous Forth Bridge. Its trusses are the heaviest ever built. There are two main spans of 1,182 and 984 feet respectively, springing from two piers erected on a mid-channel island. From end to end the bridge measures 8,725 feet, and, together with the approaches, the total length is swelled to 7,358 feet.

In its erection the somewhat unusual course of pinning its members together, at points of intersection, was adopted, instead of riveting them. The truss members of the superstructure were not built up bit by bit near the site, but put together by the manufacturers and forwarded entire on cars or groups of cars, and pinned as the erection proceeded. A very pretty bit of pinning it was too—the objects to be connected being bars and girders, some weighing 120 tons; the pins, cylinders of steel, some 16 inches in diameter and 10 feet long; the thimble, a 5-ton battering ram. And this work had to be done partly at a height of 300 feet above a deep, swift current, navigated by steamers, barges, ferries, and sailing ships, with the bitter winds raging furiously.

In the erection of this bridge, as stated, 67 lives were lost. Curiously enough, the great majority of these fatal accidents occurred among the sailors who had been engaged by the contractors because of their ability to climb. As a matter of fact, the successful modern bridge-builder must possess other qualifications than that of

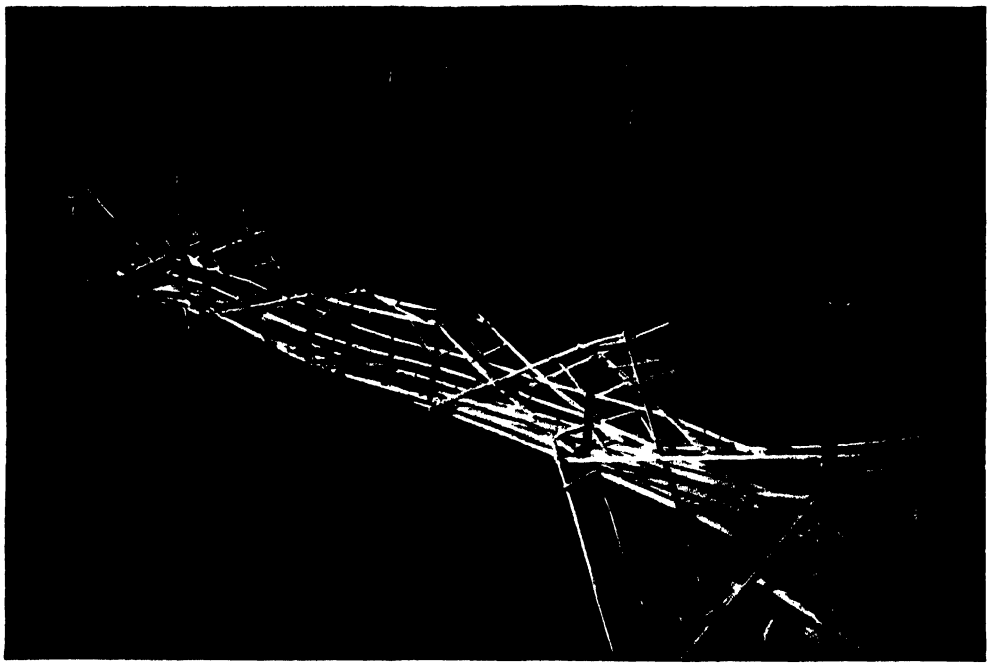


Photo by permission of the Grand Trunk Railway

A Quaint Cantilever Bridge of Timber

This bridge, simply lashed together with willow thongs, and built unaided by the Indians of the Bulkley River, is actually a true type of cantilever design

Building the Forth Bridge

This mighty bridge, with its two mammoth spans of 1,700 feet, is one of the most remarkable in the world. For no less than seven years an army of intrepid workers laboured in mid-air to complete it. In addition to £3,000,000 sterling, it cost 57 human lives

climbing. He must know something of steel, possess a clear head, and be ever on the alert.

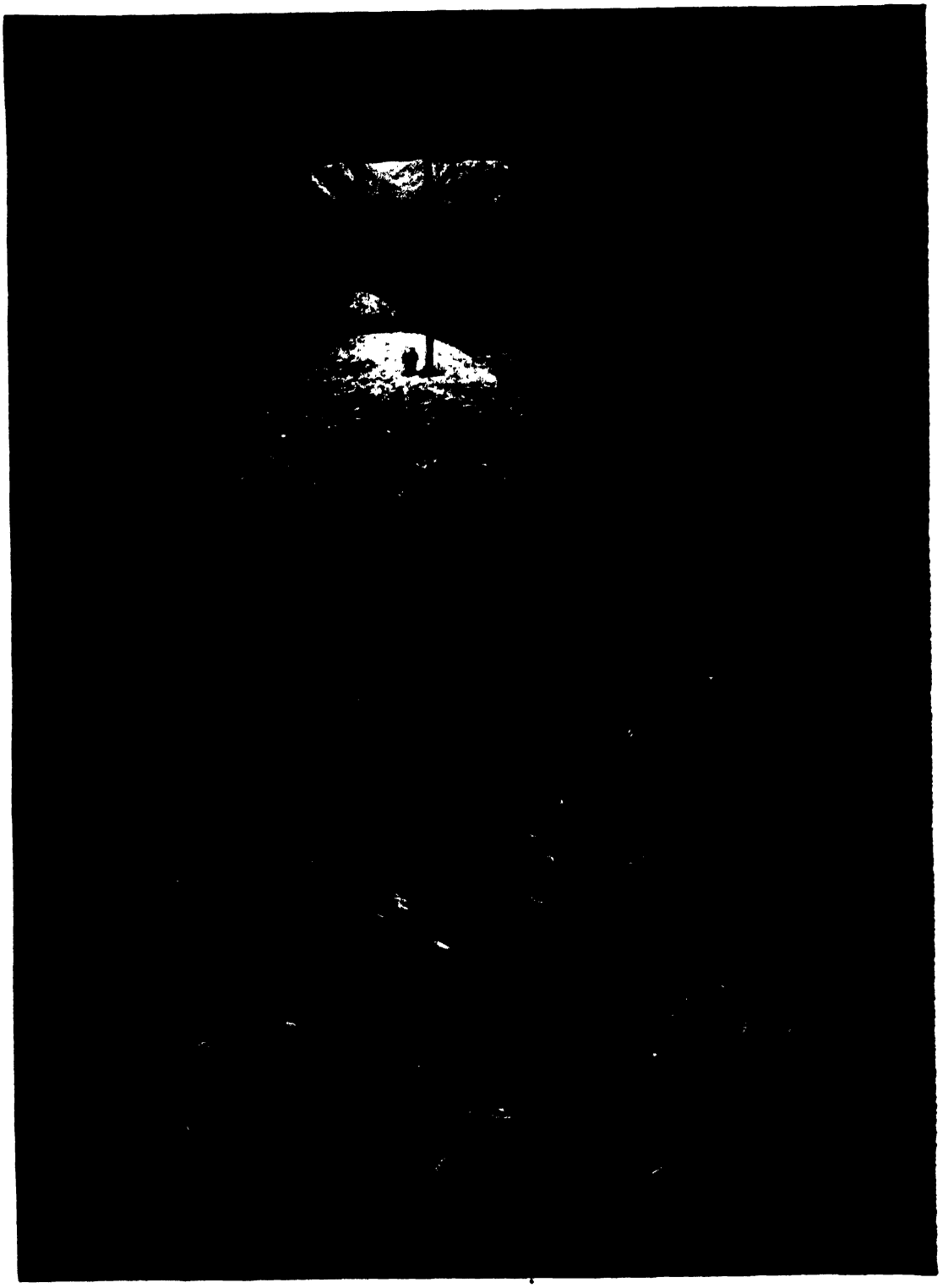
The manner in which these men climb and creep among the steel bones of the structure, walk along girders a few inches wide two or three hundred feet above the ground, swing up through the air standing upright on 40-ton girders, dangling at the end of a steel cable from a crane overhead, dodge, if they are alert enough, falling tools, bolts, or rivets, or swinging pieces of vicious-looking steel, is truly marvellous. Then, when the luncheon whistle goes, they will grasp ropes or what not, and come sliding down 300 feet to Mother Earth like trained acrobats on a theatrical stage.

So far mention has only been made of the larger steel structures, though those that have been erected over great chasms in the Rockies and yawning ravines in the Andes and other places, to make a path for the iron horse, have demanded all the pluck and resource of the engineer. For years the distinction of being the loftiest bridge in the world rested with the famous Loa structure in South America. This spidery path of steel crosses the Loa River at a height of 336 feet above the rushing torrent. Then came that wonderful structure, the Victoria Falls Bridge, over the Zambezi Gorge, some 700 yards below that mighty cataract, of which Mons. Marcel Magne has painted the Salon picture reproduced on page 250. It is a single graceful steel span of 500 feet, and crosses the gorge at a height of 400 feet above the whirling waters. The recently completed Fades viaduct, in France, has finally wrested the height record from the rest of the world. It crosses the tortuous Sioule River, at a height of no less than 440 feet.

Photo: Illustrations Bureau

A Fine Piece of Girder-work

A view of part of the Blackwell's Island Bridge, which connects New York City with Long Island



The Cavern of the Ravens

The famous Gouffre des Corbeaux, in the Department des Ariège, France, was recently explored by Monsieur Martel, the famous spelæologist, and Monsieur Maugard, who found it to be a typical charnel cave. The entrance to it is by way of a pot-hole in the Forest of Belesta, over 110 yards deep, down which for centuries past animals of all kinds have fallen or been thrown by folk who devoutly believed this to be a bottomless pit. By discovering the truth about this veritable microbe farm, which for hundreds of years has polluted the sources of water supply in the neighbourhood, the intrepid explorers have probably saved many

Spelæology

The Science of Cave Exploration—How it has Served Mankind

By E. A. BAKER, M.A., D.Lit.

Author of "Moors, Crags and Caves of the High Peak," &c.

MOST people look upon a cave as a damp and rather unpleasant sort of natural curiosity, into which they are entrapped by a mercenary showman, who asks them to admit that a certain sheet of calcite with zones of red is like streaky bacon, a range of stalactites is a good imitation of organ-pipes, and a picturesque grotto with its natural pillars and dome resembles St. Paul's Cathedral. Few indeed realise that caverns are a numerous and important feature in geography, and that they play and have played a vital part in the making and the actual life of the earth. Caves, of course, include the innumerable fissures and cavities existing in all portions of the earth's crust, penetrating often to enormous depths, where no animal could live because of the intolerable heat, and yawning even in the floor of the ocean, where vast quantities of water are being everlastingly engulfed, to generate, as scientists believe, the explosive forces at work beneath the volcanoes. This gives us some idea, not only of the multitude, but of the mighty functions of caves in the evolution of the globe.

It is from subterranean cavities of this nature that our thermal springs are supplied at Bath, Harrogate, Baden, Carlsbad, and other places. From what unknown depths came the floods of boiling water that broke into the workings when the Simplon Tunnel was being cut? The geysers of Iceland and the Yellowstone, the hot springs of the Antipodes, draw their waters from such profound reservoirs. Caves and fissures are of great antiquity in the structure of the globe, and it was into these channels that the precious metals and minerals of all kinds were forced and deposited in remote ages. Nay, it is contended that the process is still going on. At any rate, if minerals are not being forced up in large masses from below, they are still being disintegrated and deposited anew by running water, which finds its way down and down into these gaps in the earth's envelope.

Radio-activity is a frequent phenomenon of thermal springs and of caves, and it is held by the best authorities that in these underground laboratories Nature is continually carrying on the secret processes associated with that mysterious element, radium. We have explored the huge cavities whence salt is quarried or pumped as brine; but what do we know of the sources of our petroleum?

This connection between caves and minerals brings into view the relation between caves and mankind. The remote ancestors of the human race dwelt in caverns. Here they found shelters, furnished by Nature, superior to anything they could build, and far safer as a defence against the savage beasts, the cave bear, the woolly rhinoceros, the mammoth, and the sabre-toothed tiger, which roamed at large in this country when man was already established here. At Wookey Hole, in Somerset, we have what I venture to say is the spot with the longest recorded history of continuous habitation of any in these islands. Palæolithic man has left his relics there mixed up with the remains of the prehistoric beasts; his

antiquity is measured in tens of thousands of years. Recent researches have unearthed enough traces of neolithic men, the Celtic races, Romano-British, and later inhabitants to enable us to reconstruct the whole life of these people, as accurately as one can that of the people who lived in the neighbouring lake villages. In comparison with the cave-dwellings, the lake villages are modern. Wookey Hole is now the name of a village the population of which depends on the cave for its livelihood, for the water-supply of exceptional purity which comes from this source is indispensable to the work of one of the chief paper-mills in England. Like innumerable other caves, it is the source also of the supply for drinking.

Reconstructed by L. Sargent

Gigantic Irish Stag (*Cervus magaceros*)

In some caves we find the remains of the prehistoric beasts which our remote ancestors slew—the giant stag, the cave-bear, the woolly rhinoceros, the sabre-toothed tiger, and others

Here another serious question is opened up; how can we guarantee the purity of our water-supply? Cave-explorers, in various parts of Europe, have discovered that water conveyed from afar, for the supply of towns, has frequently come from caves in which accumulations of animal and vegetable remains have contaminated it with all sorts of deadly germs. On the other hand, a friend of mine saved his borough an expenditure of many thousands on a reservoir, by pointing out a plentiful underground supply in a cave. The medicinal springs, again, counterbalance in a way the mischief done by polluted sources.

This danger to life and health through unguarded recourse to the seemingly pellucid streams bubbling up from limestone caves cannot be summarily dismissed; on the Continent, and in France especially, it is a most urgent question of national hygiene. One of the accompanying pictures shows the interior of a vast "charnel cave," as M. Martel would describe it—an open chasm or pot-hole, into which for many centuries the remains of animals have fallen or been thrown, and where they lie decaying, festering, and breeding countless millions of destructive microbes. These germs of deadly diseases find their way straight into the streams that flow on through open fissures in the limestone, and, eventually, pour forth as a copious spring, without ever having passed through the beds of sand and other porous strata which, in most cases, act upon our underground water-supply as a natural filter. Superficially, these springs have every appearance of purity. Whole

towns, whole countrysides, rely upon them for their subsistence, little recking of the foul ordure through which the water has percolated.

The microbe always flourishes in darkness. There is a place in La Vendée where dead animals were interred in Roman times, and where in our own day the mud was found on analysis to be richly impregnated with microbes, alive, though in a state of suspended animation, after being buried eighteen hundred years.

M. Martel relates how he and another explorer came across the half-decayed carcase of a calf in a subterranean stream near Cahors. Some hours later they quenched their thirst at a spring some distance off, not dreaming of any relation between the two incidents. A day or two later, however, both were attacked by a species of ptomaine poisoning and were ill for several weeks.

When you remember the thousands of open pot-holes that exist in the world, all of them in communication more or less immediate with the water-supply, you will have some idea of the importance of spelæology to the life of man.

Reconstructed by I. Sargent

Sabre-Toothed Tigers

Caves were our ancestors' refuge against these and other great beasts which formerly roamed this country (It is believed by some naturalists that the stripes of the sabre-toothed tiger ran horizontally along the body, while others maintain that they were as represented here)

The Sargasso Sea

By SIR H. H. JOHNSTON, G.C.M.G., K.C.B.

WHEN the Portuguese people dwelling along the coastline of that country facing the Atlantic, began to recover from the paralysis of the Moorish yoke, to navigate the stormy seas that lay to the westward, and speculate on what might lie beyond in the way of undiscovered lands, they specially noticed —washed up occasionally on the coasts of Portugal, and still more so on the shoreline of the Azores, of Madeira, and the Canary Islands fragments of a seaweed which they called *Sargaço*. This word and the allied Castilian *Sargazo*, is derived from an old Iberian word *Sarga*, which means a "grape," and was given to this peculiar-looking seaweed, with its long, dentelated leaves, because in the axil between leaf and stem there grows a stalked, berry-like bladder, like a yellow grape in appearance. In one species—*Sargassum bacciferum*—the spore capsules also resemble grapes in appearance. These air-capsules or bladders, buoy up the Sargassum weed on the ocean surface.

Early Accounts

When the Portuguese seamen extended their adventurous voyages along the west coast of Africa, they frequently found their ships sailing through tracts of calm water thickly beset with long strands of floating Sargasso weed. But they were not the first among seafaring men to notice this phenomenon. It had been observed something like 3,000 years ago by the Phœnicians when they emerged from the Straits of Gibraltar to explore the Portuguese and Moroccan coasts, and in course of time information about these masses of floating seaweed was transmitted by them to the wonderful Greek geographers and historians of the five centuries which preceded or succeeded the opening of the Christian era. But the Sargasso Sea—that is to say, that vast circular tract of the Atlantic which lies between north latitudes 16° to 38°, and west longitudes 30° to 50°, was first definitely reached and described by Columbus on his 1492 journey westwards from the Canary Islands in search of an Atlantic route to the Indies.

The Grassy Sea

At the beginning of the second week of his voyage his two ships entered the Grassy Sea. They were almost following the line of the Northern Tropic (23° 30′), and when the Sunday morning dawned they found themselves sailing slowly through a region which resembled a vast, inundated meadow, over whose watery surface innumerable bunches of coarse, grass-like weed lay scattered. The seamen thought that this appearance on the water indicated the close proximity of land, and fortunately little realised they had accomplished at most a third of their voyage towards the northern West Indies, and that this region of thickly collected seaweed extended all the way from the vicinity of the Azores or the Cape Verde Islands to the Bahamas. They noticed, however, the small crabs (*Planes minutus* and *Neptunus*) and the small cuttlefish which frequented in large numbers this floating vegetation on the surface of the water, and were only discernible by their movements, for their coloration had been arranged so as to imitate almost exactly the weed amongst which they lived. Possibly also they observed the many pipe fish and amber fish, and the fantastically

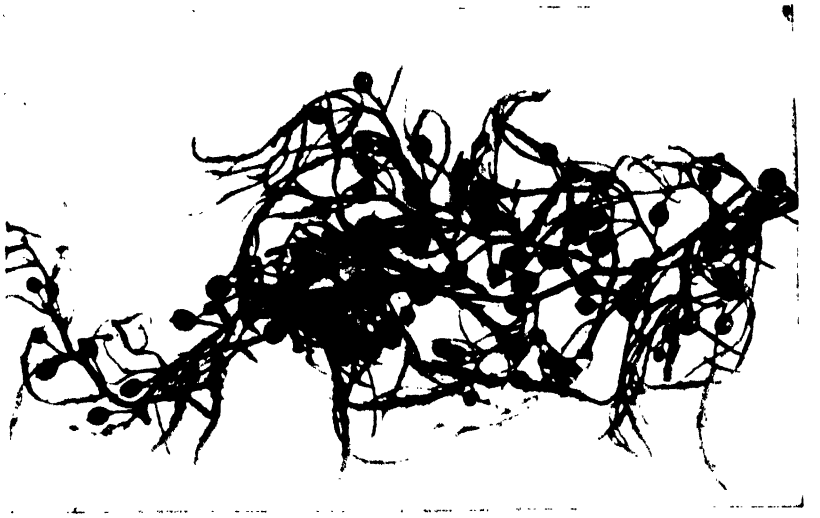
formed and strangely marked angler fish or "sea-toads," similarly developed and adorned for close association with the Sargasso weed. These last belong mostly to the genus *Pterophryne*.

There are at least five species of *Sargassum*, and their growth seems to be generated in the first instance in the Caribbean Sea and along the coasts of Central America and the West India Islands. The currents of the Gulf of Mexico apparently sweep great masses of the weed out through the narrow passage between Florida and Cuba. The Gulf Stream bears the weed eastward, and gradually the weed is sent by currents or trade winds into a vast backwater between the Azores and the West Indies.

In this backwater, which is also a region of comparative calms, the weed is so thick that it impedes navigation, and, in the days before steam, was such a source of delay to sailing vessels that, like most other dangers, it was exaggerated. Stories were told, and were regarded as credible down to quite recently, of vessels which had never been able to get out of this mass of floating seaweed, but had been held captive until from some cause or another they sprang a leak and sank below the surface, still detained in the tangle. The *Michel Sars* expedition of 1910–1911 disposed of the credibility of these legends, though it is quite conceivable that, after cycles of extraordinary growth of this weed, ships may have been imprisoned.

It is now proposed to add some account of the strange creatures which live in or on this floating seaweed. Over its surface skim the flying-fish (*see* pp. 612-613) of the genus *Exocœtus* (especially the beautiful blue-tinted *Exocœtus spilopus*; and these flying-fish are pursued by various types of Atlantic gulls. Indeed, one interesting fact noticeable in the Atlantic as compared with the Pacific, is the abundance of gulls in mid-ocean, far from land, as well as other sea-birds. Gulls are entirely wanting over the great breadth of the central Pacific Ocean, their places being taken by petrels, phaethons, and frigate birds. But over the northern half of the Atlantic, sea-birds are seldom absent from the waterscape, even at a distance of 1,000 to 2,000 miles from land.

This, no doubt, is due to the presence of the floating Sargasso weed, with all the living creatures that it harbours. The gulls, moreover, can rest secure from danger in the calm water amongst the weed-sprays or perched on the uplifted masses of weed. They subsist not only on fish but quite as



The Weed Sargassum

The Sargasso Sea varies from time to time in form and extent. It generally consists of a vast bank of seaweed, in shape like a fantastic capital T, with a stem about 200 to 250 miles broad

Drawn from the collection at South Kensington by A. Hugh Fisher

DEEP-SEA FISH: SO AMAZING THAT THEY TRANSCEND THE RANGE OF MAN'S IMAGINATION

Nos. 1, 2, 3, 4, 9, 13 and 14 are found in the deeps beneath the floating meadows of the matted Sargasso

1. **Ceratias uranoscopus: North Atlantic: 2,400 fathoms.**
2. **Paraliparis: North Atlantic: 640 fathoms.**
3. **Aphanopus carbo: off Madeira and Portugal.**
4. **Saccopharynx flagellum: Atlantic: 1,000 fathoms.**
5. **Aphyonus gelatinosus: between North-East Australia and New Guinea: 1,400 fathoms.**
6. **Melacosteus indicus: near the Philippine Islands: 500 fathoms.**
7. **Bathypterus longicauda: Middle of Southern Pacific: 2,550 fathoms.**
8. **Ipnops murrayi: South Atlantic and Indian Ocean: 1,600 to 1,900 fathoms.**
9. **Chauliodus sloani: Mediterranean, Mid-Atlantic, S. of New Guinea: 800 to 2,500 fathoms.**
10. **Halino chirurgus centriscoides.**
11. **Gastrostomus bairdi: 1,000 fathoms.**
12. **Dolopichthys alector.**
13. **Melanocœtus murrayi: Mid-Atlantic: 1,85(fathoms.**
14. **Paraliparis membranaceus: Cape St. Vincent: 400 fathoms.**

much on the smaller cuttle-fish and crabs which frequent the meshes of the weed, and which seek to elude capture by adapting themselves in colour and markings to the blackish-brown, grey-green, and yellowish-white of the berry-studded fucus.

Sargasso Crabs

The Sargasso crabs—also marked with waving lines and bands of dark brown on a yellowish or greenish-white ground, belong to two different types: the Portunids, with their last pair of legs flattened into oars for swimming, and the Grapsids, not usually a family of oceanic range, but developing in connection with the Sargasso weed-area a little square-shaped crab, the *Planes minutus*, which can scarcely be detected by the human eye, or perhaps even a bird's eye, as it clings to the weed-tangles and exactly imitates them in colour.

But the fish are the most remarkable denizens of these floating meadows. Far, far below the thirty or forty feet from the surface to which these masses of fucus may sink, there are, in the depths of the Atlantic, under the matted Sargasso, deep-sea fishes so amazing in their shapes and specialised developments (such as light-producing organs, and eyes with telescopic lenses), that they exceed the ordinary range of untutored imagination; but these live quite independently of the Sargasso weed, which may be floating a thousand feet or more above them. The fishes most associated with the Sargasso surface area are the *Exocœtus*, flying-fish; the beautiful and gorgeously coloured sea-bream; the golden-brown Amber fish (*Seriola*, a kind of horse-mackerel); the pipe-fish and sea-horses; and the frog-fish or anglers.

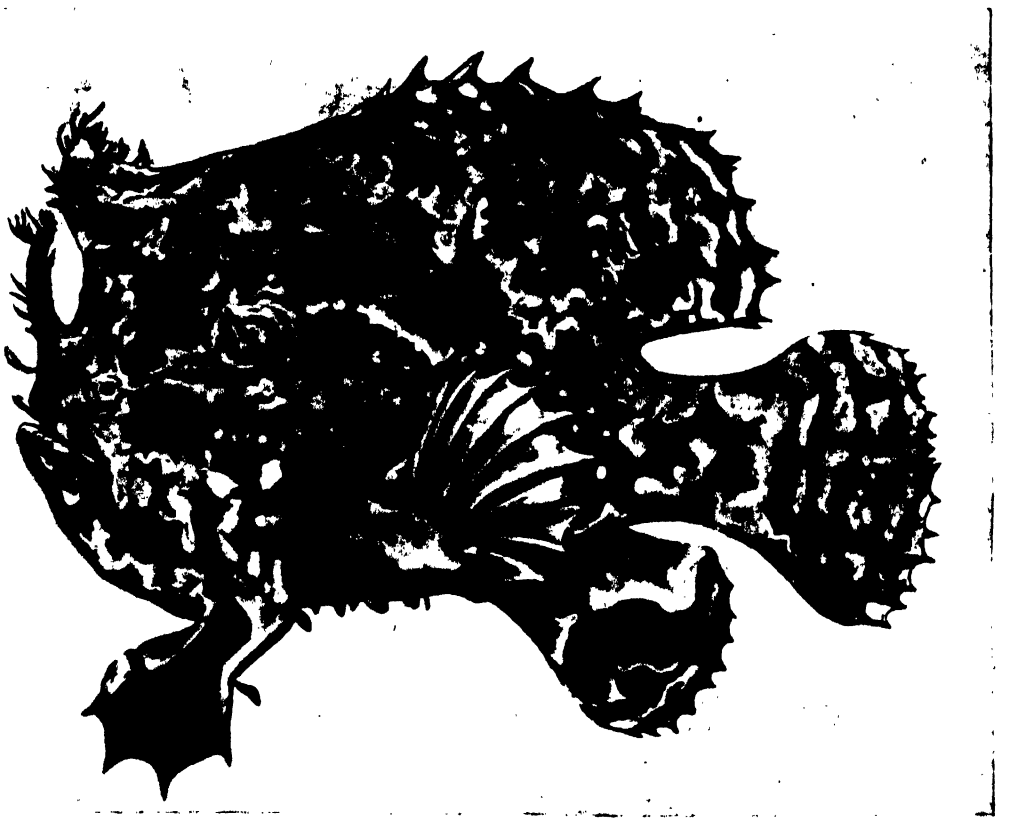
The Sea-bream (*Carangidæ*) belong to a family which is noteworthy for the extreme vividness of colouring in several of its genera, and might, one would think, be more frequently represented in large salt-water aquariums than is the case. Commonly met with below, and in the middle of these floating masses of fucus, are the most beautiful of the sea-bream, of the genus *Dentex*, some species of a gorgeous red, inclining to scarlet and mauve, and others of orange and yellow; while their relations of the genus *Pagrus* are purple-red and gold. These beautiful creatures, whose beauty, alas! is evanescent and departs with their life, are good to eat, so far as man is concerned, and sea-birds likewise; they have no strongly defensive or aggressive armament of body or mouth; therefore they must meet with many fish enemies under the Sargasso weed. But no doubt this dense vegetation protects the fish from the aerial attacks of birds, and does not make them more visible than if they were white. Some members of this family (which is closely allied to the red mullets) are hermaphrodite, that is to say include both sexes in the same individual.

Nests of Spawn

The flying-fish of this region are supposed to be the originators of the great "nests" of spawn found in the meshes of the Sargasso, though these were until recently attributed to the Antennarids and anglers, whose rafts of egg masses will shortly be described. This spawn and the decaying fucus no doubt nourish the large numbers of quaint little Hippocampi or sea-horses, and their near relations, the pipe-fish which frequent the Sargasso. In their turn these fishes (without teeth, and with very tiny mouth-openings) are preyed upon by the much larger frog-fish, and by the Antennarids, whose mouths, when opened, seem to extend straight into the stomach. The Pipe-fishes (*Syngnathus*) dart about in the surface water like straight arrows, but usually rest in an upright position, with their tails (not prehensile like those of the Hippocampi) curved round some strand of weed. They are semi-transparent, with an armature of diamond-points, and (in an aquarium) remain so still that they may be easily mistaken for fronds of the weed, swaying with the current.

The angler-fishes in these water-meadows

are of two kinds, the Frog-fishes (*Pterophryne*) and the Sea-toads (*Antennarius*). The sea-toads are usually of brilliant coloration —scarlet, for example—and frequent shallow waters round coral rocks, where they are not easily distinguishable among the many vividly-tinted anemones. But there is at least one species of Sea-toad (*Antennarius* coloured brownish or olive-yellow, with darker markings of brown and brownish-black on a ground of bluish-grey, so that they almost exactly imitate the colours and appearance of the sprays of *Sargassum* lying on the surface of the water. Even their topaz-like eyes rather resemble the berries of the weed. Their skins, like



From a photo lent to Sir H. H. Johnston by the New York Zoological Society

The Frog-fish (*Pterophryne*

One of the Angler-fishes of the Sargasso Sea

marmoratus) which has drifted out into associations with the Sargasso and developed a marbled pattern of brown, yellow and white, which assimilates it to its sea-weed home. It bears on the very extremity of its "nose" a ridiculous stalk with a tassel at the extremity. This, waving about, no doubt attracts to its eagerly-opened jaws many a silly young fish-fry, curious as to the waving bait. The Frog-fish (*Pterophryne* of several species) are those of the sea-toads, are naked or granular. Above the snout rises the usual "angling" excrescence characteristic of the sub-order; but in this case it is shaped more like a rhinoceros horn, and is decorated by a number of little waving tufts of skin resembling growths of sea-weed. All over the body and on some of the fins these tags and sprouts of weed-like skin decorate the "Actor" frog-fish (*P. histrio*) to an even greater extent than his near

From photos lent to Sir H. H. Johnston by the New York Zoological Society

Two Remarkable Types of Fish found among the Weeds of the Sargasso Sea

The largest fish is the Histrionic or Actor Angler-fish (*Pterophryne histrio*), the others are Great Pipe-fish (*Syngnathus acus*)

relations, and although these developments are not for vain display (as the naturalist Linnæus thought, who gave him his name), but for the delusion of his enemies and victims, they give the fish a very singular appearance when examined at close quarters in that wonderful aquarium at Battery Point, New York.

The Frog-fish

Pterophryne ranina, the typical frog-fish, is more handsomely marked in black, grey and yellow than *P. histrio*, but does not develop so many excrescences. In common with all other anglers or pediculate fish there is a peculiar arrangement of the limbs. The real "front" limbs or pectoral fins are pushed far back so that the finger-like rays reach nearly to the base of the tail and the unpaired anal fin. The true "hind" limbs or paired pelvic fins are situated in the front of the body, and when joined together make a kind of pedestal on which the fish can rest or from which it can take a spring. In some of the deep-sea angler-fishes the pectoral limb (which answers in relationship to our arms) is provided with an elbow joint, and develops a long paw-like fin which is used for progression over the ground by a series of leaps, the forward-placed pelvic fins serving to support the chest, while the median, unpaired anal fin props up the tail. These peculiarities are still further pronounced in the Bat-fish (*Ogcocephalus*), one species of which is probably found within the Sargasso area, in shallower water. Here the greater width of the body is not vertical as in the frog-fishes and sea-toads, but horizontal as in the common Angler (*Lophius*). And this bat-fish is really a four-legged animal, only the homologues to our legs are placed in front of the great jointed arms.

Fish are to some extent classified by the arrangement of their paired limbs (I write "paired" because they have—with bony skeletons to support them—median unpaired fins along the back and between the vent and the tail—which are not represented in the skeleton of the air-breathing vertebrates). The fish of more primitive structure (such as sharks, sturgeons, ganoids, and lung-fish), which are nearer to the branching-off point of the ancient amphibians, evolved two sets of paired limbs; the front pair starting from the pectoral girdle behind the jaws, and the hind pair from the belly in front of the vent. The two pairs of fin-limbs were separated by a considerable interval; in fact in approximate position they corresponded with the front and hind limbs of land vertebrates, of which these paired fins were the prototypes. But in the great order of the *Teleostei* (which includes all but about five hundred of the twelve thousand species of existing fish), the arrangement of the paired limbs is often such as to disguise their original purpose, one set being close to the other and immediately below it. In the angler-fishes, as in the gobies and the mackerels, the pelvic fin is often in front of the pectoral.

A Thorough Cannibal

Mention has been made of the fact that the frog-fishes are rather wider vertically than horizontally, unlike the very toad-like angler. But they can change this appearance by swelling out the abdomen till the excess of breadth seems lateral. In size the frog-fishes are not large—from three to seven inches in length—but they are ferocious towards other fishes, and have a great appetite and storage capacity. One *Pterophryne*, which was opened by Professor Möbius in 1894, was found to have swallowed and not yet digested four pipe-fish (one five inches long), a small cuttle-fish, and a little crab. The frog-fish is given to sulking inactively in the recesses of the Sargasso weed until its prey approaches within reach. It then darts on it like a tiger, and, with protruded mouth and open jaws, takes as much of its victim in at one gulp as possible. If it is a fish as large as or larger than itself (and it is a thoroughgoing cannibal in attacking its

own species), it will bite off portions and exc escences. In an American aquarium, Dr. Hugh Smith observed one *Pterophryne*, only six inches long, seize and swallow another four inches in length.

The same observer a few years ago watched female frog-fishes discharging their ova in a jelly-like mass. On contact with the sea-water, these myriads of eggs and the mucus in which they float consolidate into a raft of viscous jelly which —though it may have emanated from a little fish barely three and a half inches long—attains a length of about *forty* inches, a breadth of three inches, and a thickness of an eighth of an inch. These egg rafts dissolve after about twelve days, and the innumerable, infinitely small eggs have then hatched out into tiny embryo frog-fishes, a vast proportion of which no doubt are swallowed by other fishes, including those pipe-fish that the parent *Pterophryne* lies in wait for and devours in its adult stage.

Earthquake Waves

The Origin of One of the Most Dreaded Perils of the Ocean

By FRANK T. BULLEN

Author of "The Cruise of the 'Cachalot'"

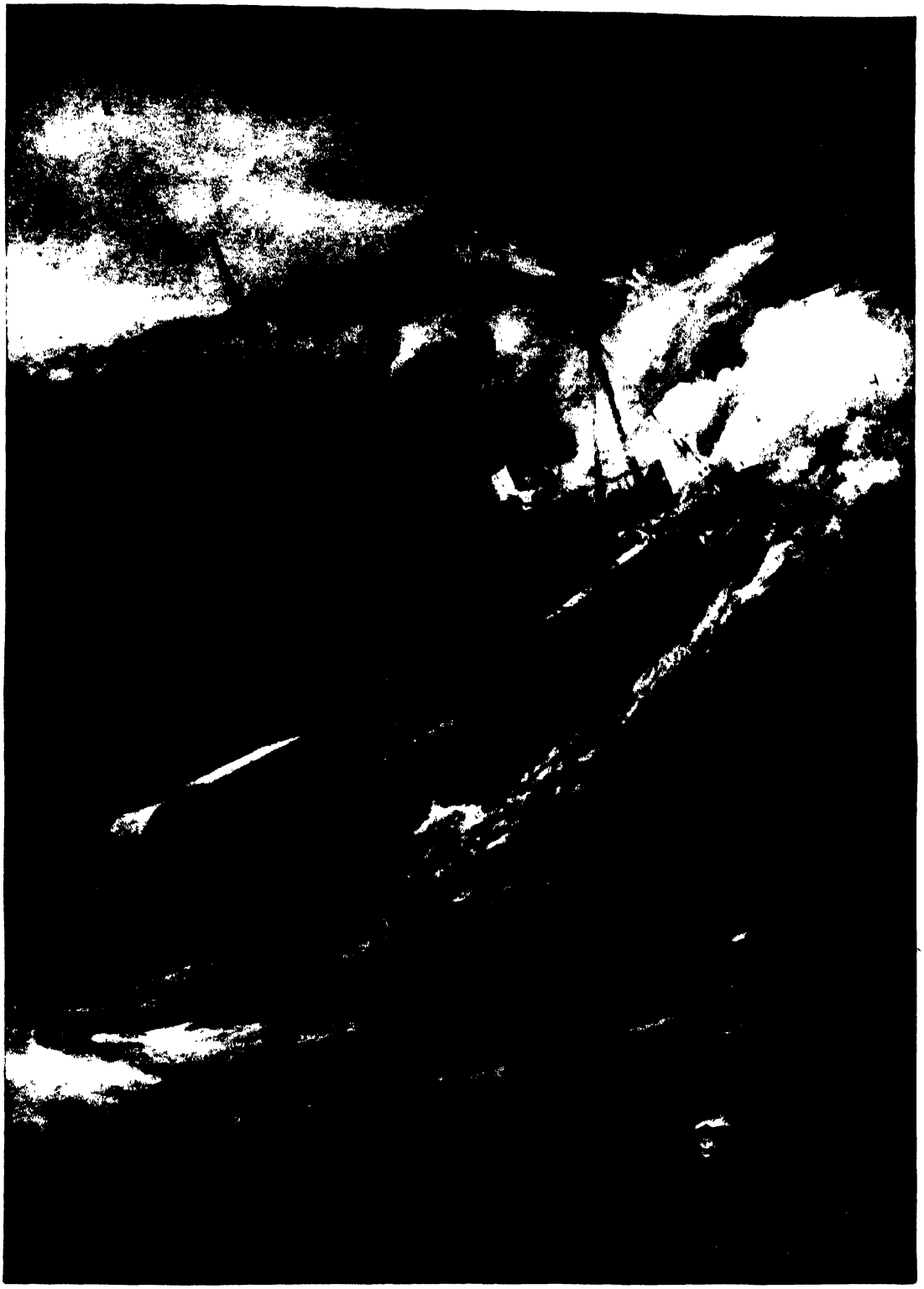
FROM time to time reports reach us of immense damage to life and property caused by what are almost invariably designated as "tidal waves," such designation arising entirely from ignorance. No fallacy could be more easily confuted if it were not for the triple-headed giant of use, wont, and ignorance.

A very little thought should convince one that the gentle, beneficent and regular action of the tides twice daily all round the world cannot be the cause of such awful outbursts of destruction as are the so-called "tidal waves." As well expect the sun to blaze up intermittently with fervent and destructive heat, leaving a swarth of smoking ruins to mark the path of its rage. Of course, it is true that in certain places, and under certain conditions, the incoming tide does attain great force and volume, as in the "bore" of certain rivers, but even these phenomena, though they may occur at spring flood-tides, aided by a gale behind them, never attain to the awful dimensions of what is popularly known as a "tidal wave."

Superficially considered, it would seem quite natural to suppose that the cosmic action of the moon, in heaping up the waters of the ocean beneath her in her daily path round the earth, in order to produce the tides, would, of necessity, cause an immense wave to roll right round the globe, twice every twenty-four hours. Only, if that were so, every ship that sails the sea would certainly meet this tremendous wall of water, wherever she might happen to be, twice a day, and it would necessarily be of such dimensions that it is perfectly certain very few ships indeed could survive the meeting.

Indeed, none could, unless they met the oncoming wave under the most favourable conditions—that is to say, bow on; if it took them on the broadside its impact would be quite sufficient to bowl over the world's most powerful liner.

No; the reason for the occasional up-



The Onset of an Earthquake Wave

(Drawn by Norman Wilkinson)

No ship could survive such an onslaught unless it met the oncoming wave under the most favourable conditions—that is to say, bow on; on the broadside its impact would be sufficient to bowl over the most powerful liner

risings of the ocean, in these terrible waves, is to be found in a totally different and irregular set of conditions. Mankind has often been compelled to witness the rending asunder of the dry earth's crust in a terrestrial earthquake or a volcanic eruption, and an awe-inspiring experience it is, never to be forgotten by the survivors. Whenever such a cataclysm has happened near the sea coast it has invariably been noticed that it has been attended by a remarkable movement of the sea, which first recedes to an unprecedented distance and then returns in a veritable mountain of water, which, rushing for miles inland, completes the destruction begun and partially carried through by the earthquake.

It may be asserted quite safely that the number of earthquakes and volcanic eruptions occurring beneath the ocean surface is, proportionately, as much greater as the area of ocean is greater than that of the land. That is to say, roughly speaking, three times as many earthquakes and eruptions occur under the sea and out of man's ken (except for the earthquake recorder or seismograph) as happen on dry land. For this we should be profoundly thankful, since, although a great proportion of these terrible events take place in uninhabited regions, a sad number of them do occur where man and his handiwork are very much in evidence, as witness, in recent years, St. Pierre, Kingston, Valparaiso, and San Francisco.

Earthquakes at Sea

Now the chief characteristic of a volcanic eruption, and in a lesser degree of an earthquake, is the rending of the earth's crust apart, affording a vent to the inconceivable incandescence below. I have used these two long words because they strictly apply, since no heat that we can produce on earth, by any known means, will compare with those interned fires. Nor can the mind grasp the idea of the enormous area of fervent heat exposed by the opening of the earth's crust. But, within our limitations, we can imagine the effect of the sudden opening of this mighty furnace of fire to the inrush of countless millions of tons of superincumbent sea. When water meets fierce flame, in the ordinary way, it is immediately decomposed, and becomes gas of enormous expansive power, and here we have the process carried out on a cosmic scale. Perhaps the sea at the spot is a couple of miles deep—I only take that as a medium, since depths of six miles are met with—but the effect of that terrific meeting of water and fire is presently felt on the surface and extends over thousands of square miles.

Curiously enough, the effect of these earthquake waves is, in most cases, felt in such lonely isles of the sea as Ascension and St. Helena, the latter, indeed, being peculiarly subject to them, where they are known by the trivial name of the "Rollers," but they do occasionally hurl themselves upon the mainland with disastrous results. But we must thankfully admit that the damage done is trifling when compared with that effected by earthquakes on land. We do not know how many ships, meeting such waves, are lost, because the destruction is complete; the stout vessel disappears like a punctured bubble, leaving no trace behind, and she is in due time entered in the loss book at Lloyd's under the fateful heading of "Missing." Unhappily, there are many ships over whose going this dense fog of uncertainty hangs, and will ever remain.

But perhaps the most poignant fact connected with the earthquake wave is the alteration of the currents by the upheaval of the earth beneath the sea. It is not reasonable to expect shore folk to understand this, or to interest themselves in it, but they may take it as a certainty that a very large proportion of the ghastly tribute claimed by the sea from its mariners is levied through the agency of these unknown currents. No sailor, however experienced, can predict the unknowable.

A Ghastly Tribute

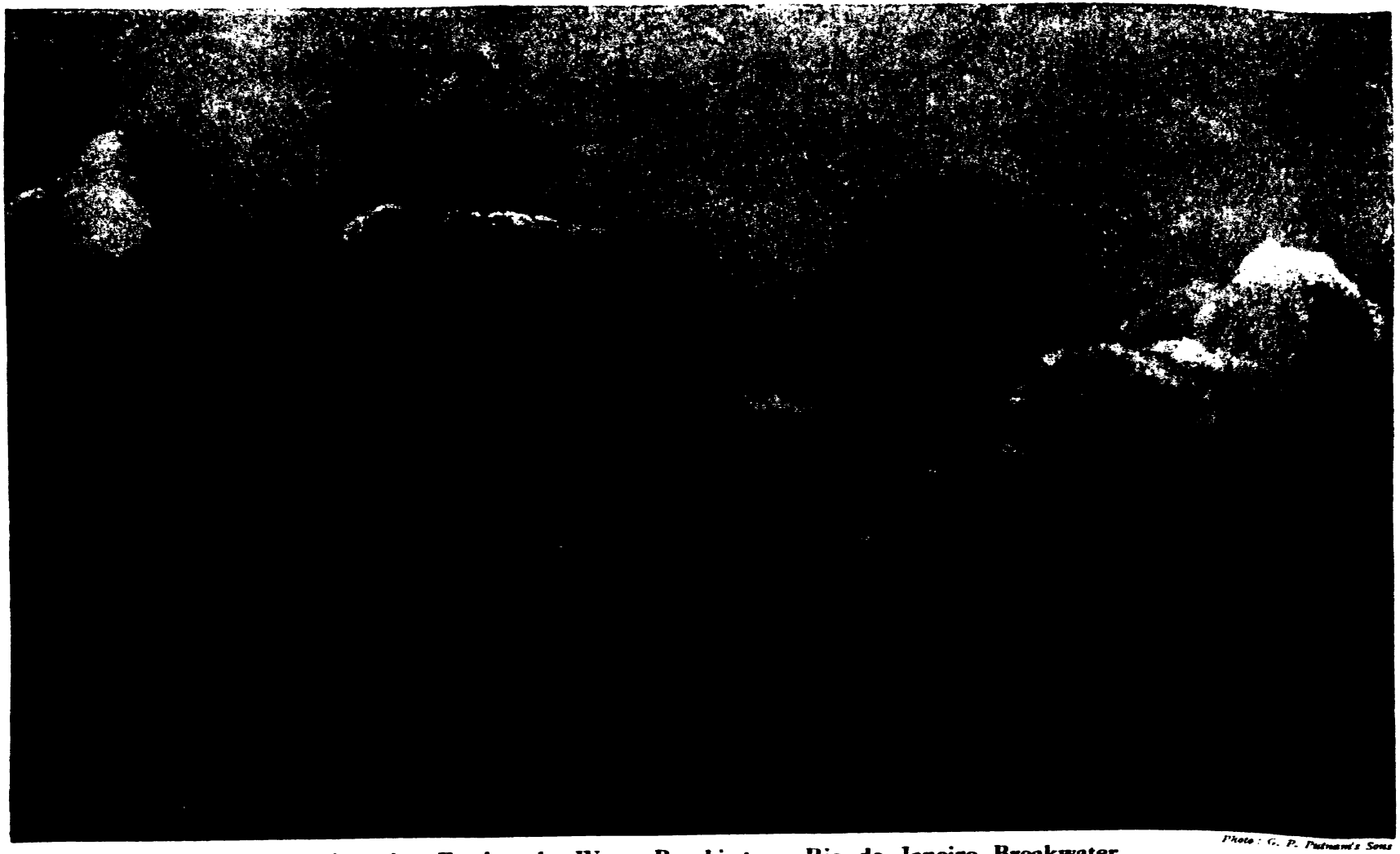


Photo: G. P. Putnam's Sons

An Amazing Earthquake Wave Breaking on Rio de Janeiro Breakwater

According to the accounts of those who witnessed this wonderful phenomenon, the towering wave looked more like solid rock than water. To the beholder's eye it seemed to tower almost as high in places as the Sugarloaf Mountain (in the background) which overlooks Rio de Janeiro

Shells Washed up on the Beach after a Gale

The Architecture of Shells—I

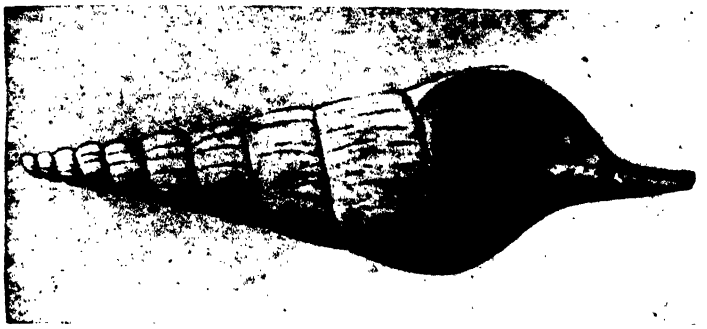
By STANLEY C. JOHNSON, M.A., D.Sc.

THERE are many ways of classifying shells, but specimens are most frequently grouped under the three heads—univalves, bivalves and multivalves. The univalves are by far the largest family, claiming, roughly, three-quarters of all the testacea: of the rest, the bivalves form one-fifth, whilst the remaining twentieth are classed as multivalves.

The normal form of the univalve is a spiral, but scientists tell us that the original shape was a simple cone, which served as a tent to protect the soft body of its inhabitant. As the creature passed from infancy to adolescence, additions to its structure were made in order that room should be provided for its growth of body. The shell thus became elongated, and, after a while, toppled over to one side. This happened because the dorsal side of the animal was the heavier. In this form, with its base exposed, it became an easy prey to its numerous foes; a more or less curved wall was, therefore, thrown out, to make the entrance a horizontal and not a vertical one. This, through constant repetition, induced by growth and a desire for more room, produced the spiral form.

It is interesting to note that Nature has always shown a great partiality for spiral designs, having produced them in such widely different things as plant tendrils, the horns of animals, cyclones and sand storms.

Of the spiral shell, there are numerous



Rostellaria curta

A fine example of elongated spiral

well-distinguished varieties, but the squat-shaped winkle, the elongated whelk, and the flat-coiled ramshorn snail are more or less typical of most others. In many cases, however, we find that some portion of the shell has been unduly developed, usually at the expense of its other sections. In the ormer, for instance, the last whorl of the spire is unusually large, whilst the remainder of the spire is so dwarfed as to be almost unrecognisable. The same thing happens in the harp shell, though in this case the final coil is quite unlike that of the ormer.

Many spiral shells are quaintly ornamented. The harp shell and its checkered ally, the Cassidaria, are models of gay colour and rich design; the interior of the ormer is a feast of glittering mother-of-pearl, whilst the scorpion shell is positively grotesque in shape. What purpose do these peculiar properties serve? Undoubtedly, the calcareous spines and bands of the scorpion enable it to resist the attacks of predatory foes, but it is difficult to say why the harp and other shells are decked with colour schemes, many of which rival those of the rainbow, especially as their exteriors are usually begrimed with mud and slime, which totally hide their beauty. Of course, these delightful hues serve for purposes of protective mimicry, but this can only be a partial explanation.

Just as the univalve is admirably adapted to a life spent in clinging to other objects, so the wedge shape of the bivalve fits it for a burrowing existence. The cockle and the mussel, it is common knowledge, can easily bury themselves in moist sand, but it is less known that their near relative, the piddock, penetrates into wood and even rock with the utmost facility, and causes untold damage to pier-heads and the sides of ships. This it is able to do partly through its pointed shape, and partly owing to the fact that its covering is hardened by the presence of arragonite.

As the composition of shells varies, it is well to say a word on this subject. Some specimens, when fractured, show a dull lustre, resembling the edge of a freshly-broken piece of china; they are described as porcellanous. Others, like the oyster, are laminated, and consist of prismatic cells composed of carbonate of lime; then there are horny shells, glassy shells, translucent shells and nacreous shells. To the latter class belongs the ormer.

The growth of a shell offers many points

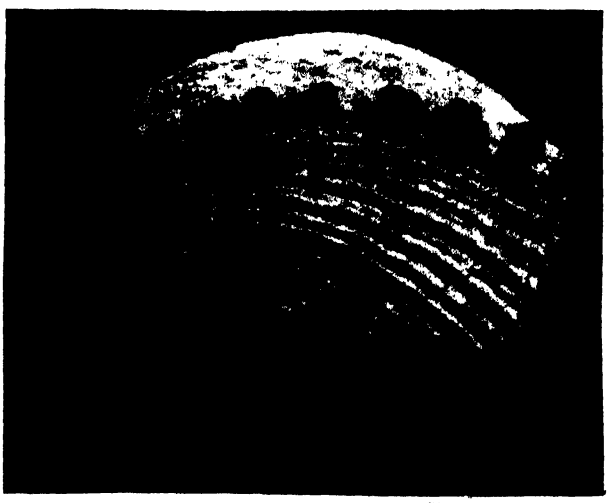


Photo Stanley C. Johnson

The Ormer Shell

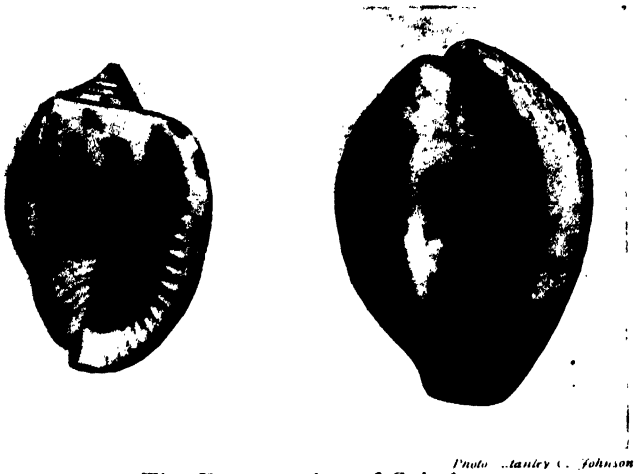


Photo Stanley C. Johnson

The Degeneration of Spirals

In the Cassidaria on left the spiral can be seen almost disappearing, while in the Cypræa mauritiana on the right it has entirely disappeared

of interest. Every part of the mantle or external covering of the mollusc can secrete shelly matter, but the proper organ for undertaking this work is the margin. In ordinary cases of growth, the margin makes the additions, but when repairs to the spire or inner whorls are necessitated, as the result of accident or excessive wear, the nearest portion of the mantle attends to the matter. All details of sculpture on the exterior surface are the work of the margin and were at one period situated on the lip of the shell. The illustration of the scorpion clearly shows that the spires are merely elaborate extensions of the lip. In the picture, they are shown in a cleft condition; in time they become filled with solid matter, and, as the margin adds to the edge of the shell, so they lose their place as lip ornamentations and become ordinary whorl spines.

The coloured designs which shells bear are also the work of the mantle border, for in this portion of the creature alone are situated the pigment cells. When repairs are made in a shell, elsewhere than upon the lip, the colour markings must, of necessity, be absent. It is an interesting fact that shells fashioned in shallow water are, as a rule, brighter and more vivid than those which originate in deeper water; on this account, it is surmised that the action of light has some effect on colour secretion.

Certain shells which are originally of spiral form have the remarkable property of changing into curved cylinders. When this is about to happen, the inhabitant of the shell descends from the upper whorls of the spiral, and a septum or crack appears near the apex. Shortly after, the upper section falls away. When this process has been repeated two or three times, all appearance of the spiral form is lost, and the shell looks somewhat like the horn of a young sheep.

Another family which loses its spiral form is the *Cypræidæ*. In the youthful stages, this variety of shell possesses a diminutive spire, but, as age creeps on, the surface of the lower whorls becomes enveloped with shelly lobes to such an extent as to hide the apex completely. Eventually, the spire disappears altogether.

Photo: Stanley C. Johnson

Scorpion Shell

Observe the elaborate cloven spires on its lip

Life-saving Bells

Concerning the Wonders of Submarine Signalling

By HORACE C. DAVIS

MODERN enterprise has overcome to a great extent the terrors of the storm; it has lessened the chances of serious fire at sea; it has so fixed up definite and well-understood rules of the road that the collision nightmare is nothing to what it was, notwithstanding the fact that the seas of the world are getting more crowded year by year. It has most of its dangerous reefs and shoals carefully charted and marked by light-house and light-vessel, so that there remains but one dangerous enemy to subdue, and that perhaps, the greatest, namely fog. It is only within the last few years that a really effective apparatus has been found for fog signalling, not this time by giant megaphones operated by steam power, sirens, whistles, signal guns, or through the dense and, at all times, inconstant atmosphere, but through the sea.

Photo by permission of the Submarine Signal Co.

Lowering the Tripod for the Electric Bell

Scientists and inventors for over twenty years previous to the invention of submarine signalling wrestled unsuccessfully with the problem of sending a message through water by sounds, and, when this was conquered, there yet remained the further problem of finding the direction of the signal on a moving vessel at sea. To-day these difficulties have been surmounted by fitting two small tanks filled with water on either side of the bows of the ship at a suitable distance from the prow. In each of these tanks are fixed two telephone transmitters of special construction, one forward and one aft. The two forward transmitters or microphones (that is, one in each tank) form a carefully paired "A" set, the two after ones an equally paired "B" set; these, being duplicated, afford a check one against the other. The sound from the bell passes through the water from the transmitting vessel and through the liner's plating, and is received in her tanks, then transmitted electrically to the chart house, or bridge. Here is fixed the indicator box, with its telephone receivers hanging on either side. On the front of the box are two switch handles, one of which connects up with the "A" set, while the other connects with the "B" set, by turning in the opposite direction. Both the receivers are used by the officer listening for any sound of a warning bell, although they are only connected to one tank at the same time. Consequently, should the bell only sound indistinctly when the semaphore on the indicator reads "Star-

Photo by permission of the Submarine Signal Co.

View of the Tank in which the Microphones are Immersed

board," then the port tank must be tried; if immediately the sound is loud, it proves that the warning ship is away to port. Should the sounds of the bell be equally loud both through the port and starboard tanks, then assuredly the warning ship will be dead ahead.

We will now turn to the sound producer, and here we find just an ordinary loud-toned bell, with a complicated mass of mechanism to make it toll. This is done by compressed air, or electricity; in several of the lightships air is used, in most of the shore stations electricity. When fixed off shore the bell is placed on the sea bottom, suspended from a strong iron tripod, and connected with the shore by a cable. Buoys are also made that not only carry a lantern for clear nights, but a submarine bell for all times, for the bell never ceases working, no matter what the weather is. It is operated by the action of the waves, and is a very ingenious contrivance, for, no matter how calm the weather, the bell, on an average, will strike fifteen times a minute. In addition of this there is a yet simpler form of submarine signalling apparatus, to meet the great difficulty experienced by officers when ships have been abandoned and the lifeboats have to be kept within reach of one another, so that they can be kept under one command and on the best course. The device is simply a disc of bell metal, rung by hand by means of a rope below the surface. By this means a boat can notify its position to any boat or ship fitted with a receiving apparatus.

Submarine signalling, the wireless telegraphy of the water, is at present still in its infancy, but in course of time the apparatus will be made infinitely more perfect than it is to-day, and probably there will be an advance of submarine telephony. Voices will be carried through the water by waves of sound, just as the sound of a bell or any other submarine noises, such as the beat of a ship's propeller, or the wash of the surf, can now be distinctly heard.

All the modern ocean liners are equipped with submarine signalling plant, and at the present time there are over thirty-two light vessels round the United Kingdom

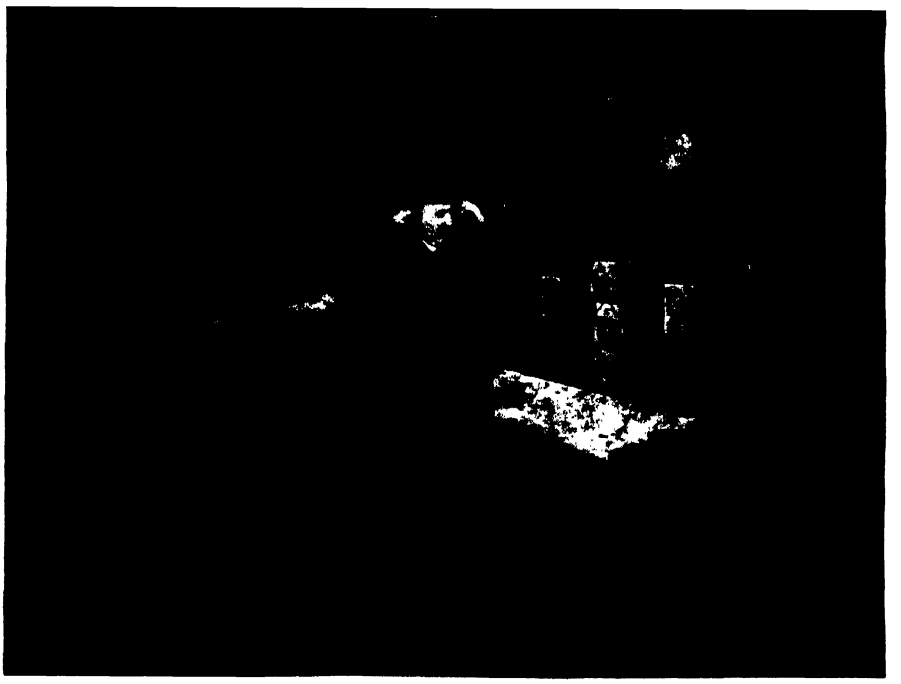
Photo by permission of the Submarine Signal Co.

The Indicator Box for the Receipt of Submarine Signals

so equipped, and most of the important lights of Germany and France have been furnished with the submarine bell. Besides these, there are fourteen shore stations in service in various parts of the world, and over thirty buoys and light vessels so fitted on the Canadian and United States Atlantic coast, besides others on the Pacific side and on the Great Lakes. Every year the bell had the stricken vessel carried an emergency submarine bell she would have been found many hours earlier.

"During our twelve hours' search I estimate we travelled two hundred miles in our zigzag course," wrote Captain Ransom later, "before we found her, and all within a sea area of ten square miles."

Every sailor is aware that in cases of

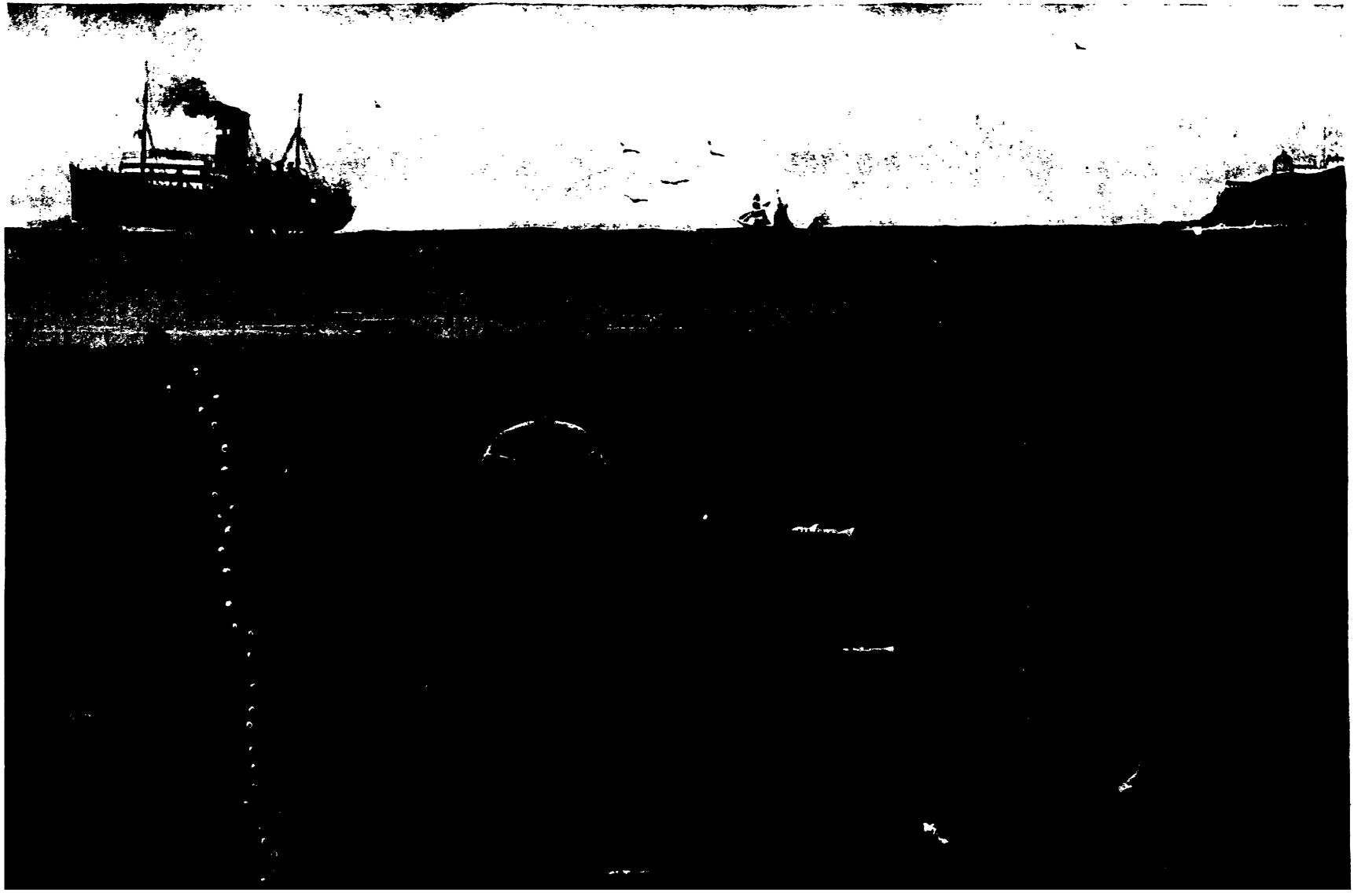


Receiving a Submarine Signal on the G.C.R. "Bury"

is getting used more and more. What it means to a vessel in imminent danger can be understood from the experiences of the *Baltic* at the time of the disaster to the liner *Republic*, in January, 1909. The *Republic* had wireless, but no submarine bell; she therefore signalled the *Baltic* by the former only.

The big White Star boat immediately went to her help, and for twelve hours zigzagged about in the prevailing fog, changing her course as every new piece of information came by wireless before she ultimately found the unfortunate *Republic*. Luckily she was still afloat, but this kind it is vital that the help should arrive at the earliest moment, as the *Titanic* and *Volturno* disasters clearly demonstrated at a later date.

In submarine boats the apparatus has been found of great value, and these underwater fighting ships have now a method of signalling to each other when submerged. In fact the American submarine *Grayling* controlled the movements of another boat, when seventy feet below the surface, by orders given through submarine bell apparatus, which gives some idea of the wonders and possible future of this remarkable invention.



How Life-saving Bells are Fixed and Worked

(Drawn by G. H. Davis)

A. Position of receiving apparatus in bow of ship
B. Tripod and bell attached to a lighthouse.
C. Electric cable.
D. Diver laying a submarine bell.
E. Submarine bell suspended from a lightship.
F. Submarine bell buoy.
G. Hand-worked boat gong.

People Who Live in Hives

IT is not always realised among civilised people that the primitive dwelling-places of native tribes are often the result, not of ignorance, but of necessity. In a country, for instance, where stone is not obtainable, the reasonable traveller does not expect to find ornate mansions; if, in addition, large timber is conspicuous by its absence, he will discover, if he tries, that it requires considerable ingenuity to secure building material of any kind whatever. In fact, if he has to depend upon his own resources, unassisted by tents, or other conventional camp equipment, he will probably, before long, be driven to admire the cleverness of the natives who manage to erect some sort of waterproof dwelling-place in such difficult circumstances.

In Mesopotamia the traveller sees a quaint form of dwelling, built of mud bricks in the form of a hive. Villages and whole towns in this peculiar form of architecture are met with. As the country is destitute of trees from which to hew rafters, and also devoid, in parts, of stone, the natives build their habitations of sun-dried mud bricks with high and steep domes, similar in shape to a bee-hive. One illustration depicts one of these beehive villages not far from Aleppo, on the route of the famous Baghdad Railway. Each home consists of several of these hives standing near together, and surrounded by a wall of similar material. One or more is used to live in, another for the animals, and still another serves as a granary, and so on, according to the possessions of the proprietor.

Photo Underwood & Underwood

The Village of Yambuya, Congo Free State

Upon a skeleton of sticks the natives make a thatch of leaves and clay. The steep pitch of the roofs is designed to make the rain run off rapidly before the very inferior thatch is penetrated

In the Congo, also, veritable beehive villages, built in this case of sticks, leaves, and clay, are met with. But for the presence of its dusky, rubber-gathering inhabitants the traveller might easily mistake a native village with its steep-pitched, hive-like roofs, for a Brobdingnagian bee-farm.

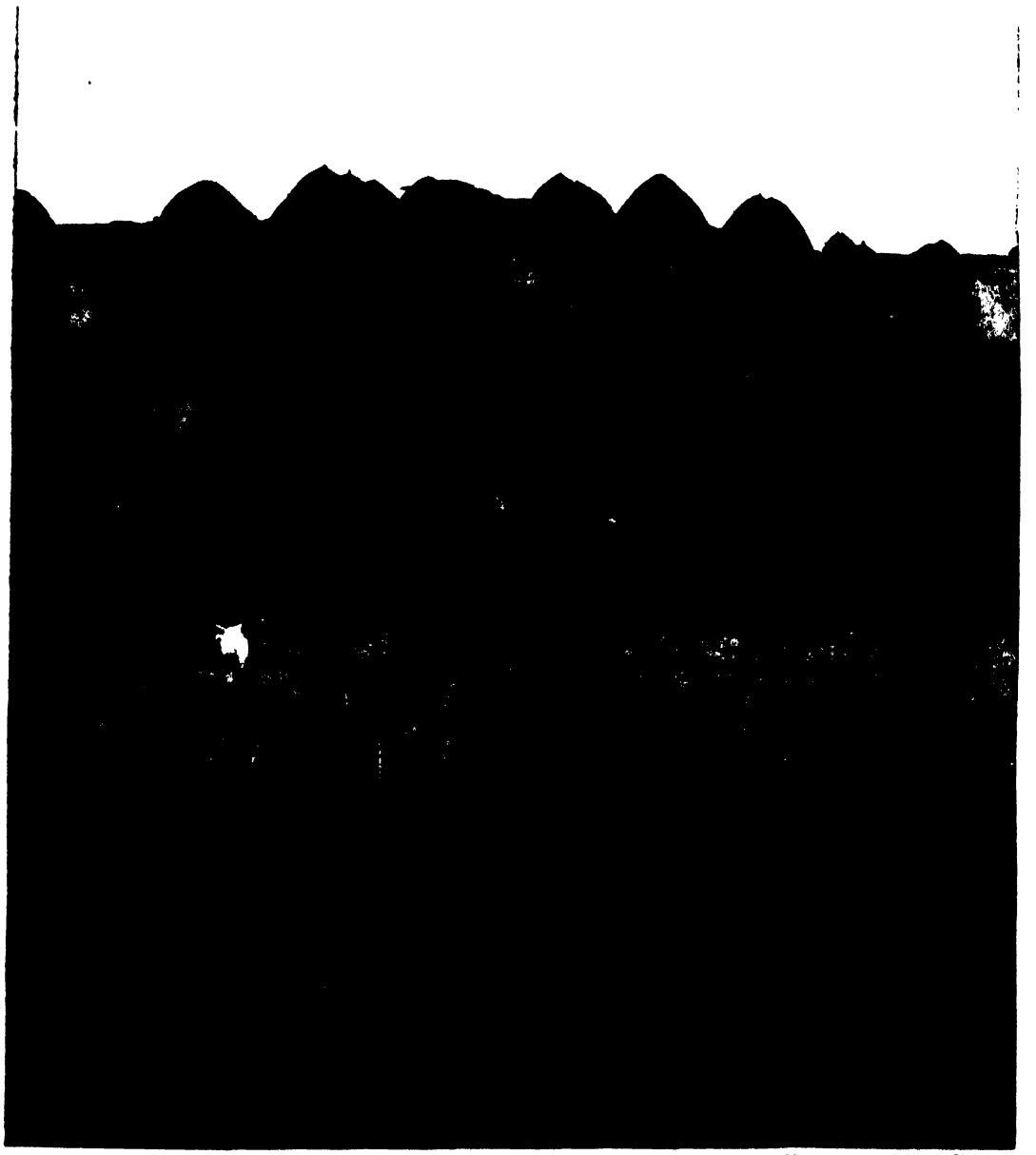


Photo American Colony, Jerusalem

Moselmieh, a Beehive Village on the Baghdad Railway, near Aleppo

Each home consists of several of these hives standing near together—one to live in, one for the animals, another for a granary, and so on

Silver from Clay

The Remarkable Story of Aluminium

By HOWARD TRIPP, M.A., Ph.D., F.C.S.

THE latter part of the nineteenth century will ever be memorable for the marvellous additions it contributed to natural knowledge, and for the successful application of much of that knowledge to the problems of industry. It is probably true that knowledge of human nature has made little, if any, progress since the days of ancient Greece and Rome; but our knowledge of, and power over, Nature has made such enormous strides forward, that we feel there is, after all, some justification for calling man *Homo Sapiens*.

Who would have imagined, even a hundred years ago, that the very mud we scrape off our boots would, under the influence of the magic wand of Science, have furnished a beautiful metal, which rivals silver in its lustre, and is capable of being put to a thousand and one different uses?

First Isolated

Aluminium is a normal constituent of all clays and of a large number of rocks and minerals, including even the precious gems, ruby and sapphire. From each and all of these it can be extracted by chemical or electro-chemical means. It was first isolated in 1827 by Wöhler, but it took sixty-four years of strenuous and unremitting toil to devise a method of extraction that was both economical and capable of being wo ked on an industrial scale.

Aluminium was first manufactured, in 1854, by a chemical process discovered by St. Claire Déville, who was assisted financially in his researches both by the Emperor Napoleon III. and by the French Academy of Sciences. This brought down the price from £53 to £18 per pound, and later, when Déville exhibited his "silver from clay" at the Paris Exhibition of 1855, the price receded further, to £12 per pound.

The early methods employed were purely chemical processes, and, as they mostly involved the use of the metal sodium, they were costly. Even to-day it would not pay to use a sodium process; the best devised would be only commercially possible if sodium could be obtained at ½d. per pound, whereas its present cost is about 2s. 6d.

What is Electricity?

The key which finally unlocked the door to success was the application of electricity, the method first used by Bunsen in 1854. Of all forms of energy, electricity has perhaps been the most potent in transforming the daily, material life of civilised man; yet, in spite of that, we can hardly yet say that we *know* anything definite about its real nature. An examiner once asked his victim what electricity was. The nervous wretch, not perceiving the irony of the question, replied that he had quite forgotten, although he had known it perfectly on the day before, whereat the examiner conjured him to recollect at all costs and thus make known one of the greatest discoveries of the age. Wonderful and ingenious as have been the successive theories that have emanated from the fertile brains of gifted scientists, he would be a bold man who would enunciate a final solution of the problem.

The electrical extraction of aluminium is only possible where electricity is cheap, and cheap electricity can only be obtained where an abundant supply of water-power is available. Unfortunately, the British

Isles are sadly wanting in what has been called "this gift of topographical configuration"; nevertheless, a British company has seized upon and harnessed two of the very few possible sources of water-power in these islands, viz., the Falls of Foyers, and the waters of Loch Leven in Argyllshire, and made them available for industrial purposes. The same company has also established works in Norway and in Switzerland, so that the total capacity of their combined works exceeds the enormous figure of 60,000 h.p. The Niagara Falls in North America, and the Falls of Schaffhausen, in Switzerland, have likewise been commandeered in the interest of aluminium production.

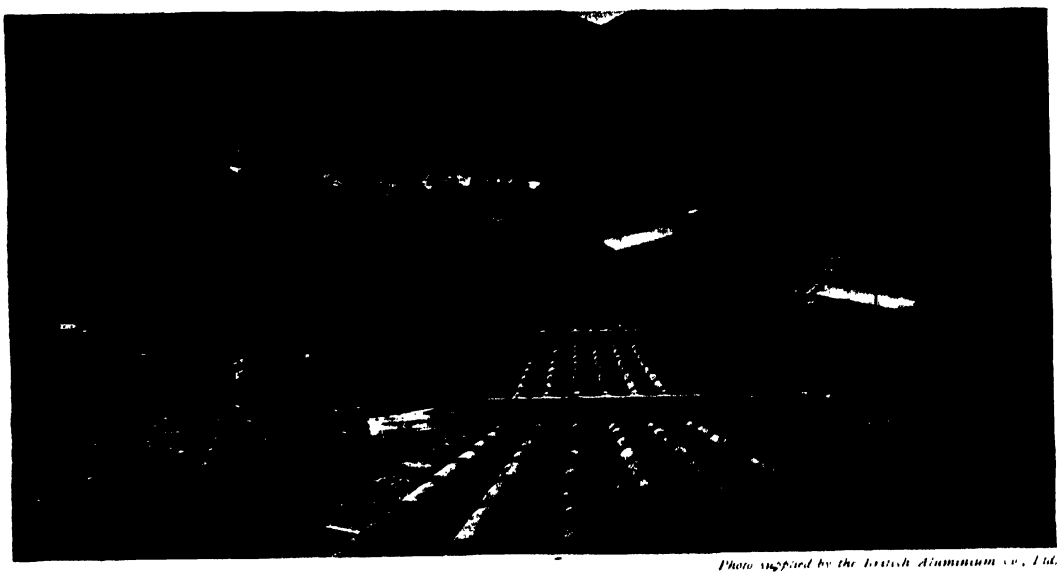


Photo supplied by the British Aluminium Co., Ltd.

The Lower End of the Hydro-electric Pipe-lines at Kinlochleven

At a distance of 5½ miles from the head of Loch Leven, a huge concrete dam, about ¾ of a mile long and 80 ft. high, has been erected to pen up the water of three neighbouring lochs. This water is conveyed from the dam through a conduit, also made of concrete, and nearly 4 miles long, to a series of parallel pipe-lines. These carry the water for 1¼ miles to the generating station at Kinlochleven, where its pressure rotates the water-wheels or turbines, and these in their turn communicate their motion to the rotating parts of the dynamo. The electric current generated by the latter passes by cables direct to the electrolytic cells or furnaces, where the process of extraction, patented independently by Héroult in France and by Hall in the United States, is carried out. The materials used at Kinlochleven are purified alumina, obtained from the mineral "bauxite," a kind of clay which comes from Ireland, and "cryolite," a white, ice-like mineral from Greenland, which easily melts.

The furnace employed is made of an iron framework, measuring 5 ft. by 2½ ft., thickly lined with compressed carbon. The powerful electric current passes in through the long rods of gas-carbon, traverses the mixture of alumina and cryolite, which it first melts and then decomposes, and makes its exit by way of the separated aluminium, which collects in a molten state at the bottom, from which it is run out through a tap-hole.

Although the temperature of the furnace is 1,600° F., there is no need for external heating, as the current provides all the heat necessary. The cryolite undergoes no

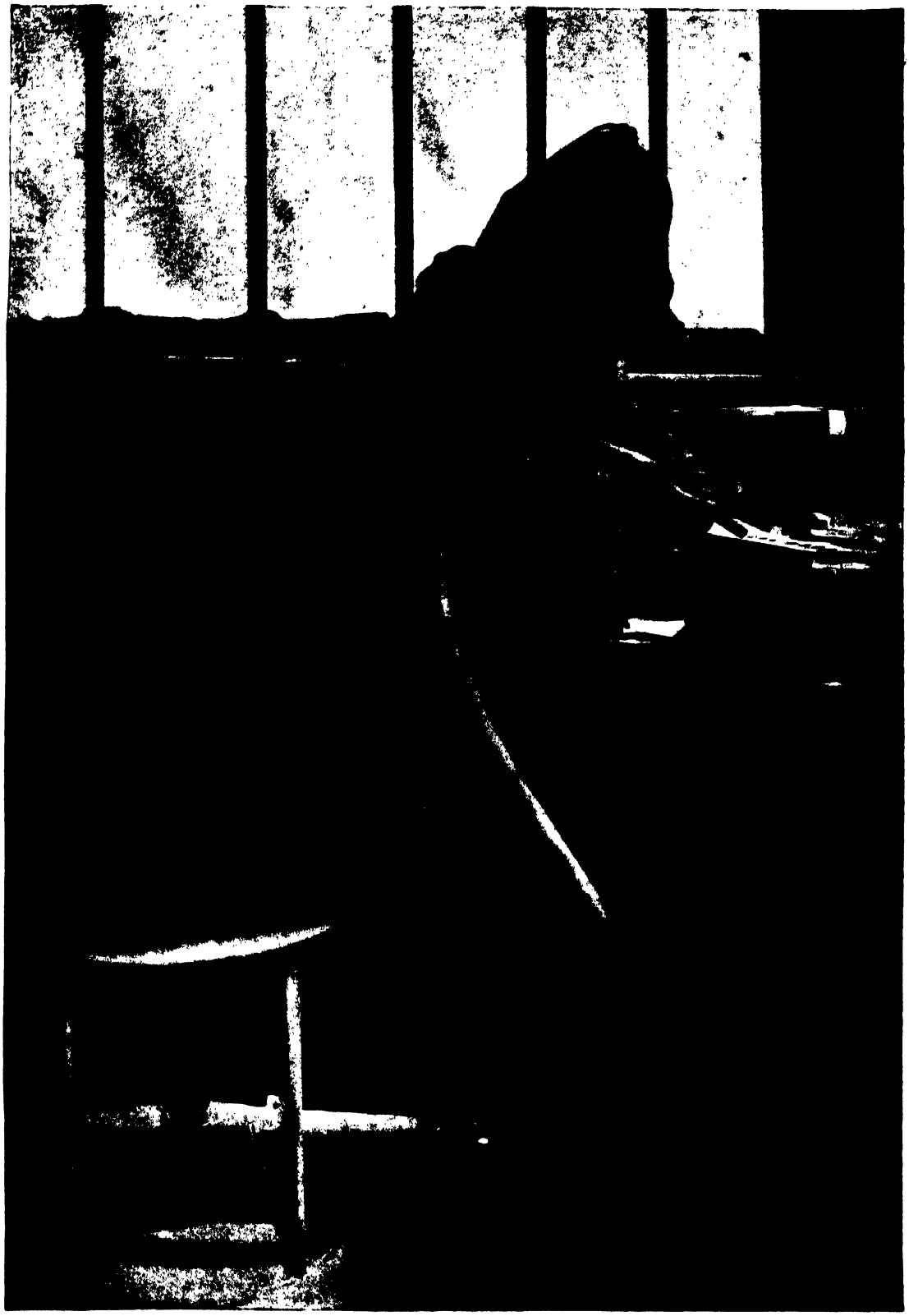


Photo: J. Boyer, Paris

Finishing an Aluminium Part

The photograph shows a workman, his eyes, ears and mouth carefully protected from injury by a helmet and goggles, employing the sand-blast to finish off an aluminium casting

change; the alumina alone is split up, so this material must be added from time to time to replace that which has been decomposed. So obtained, the aluminium is remarkably pure, containing only a little iron and silicon and traces of carbon.

The world's total production of aluminium in 1889 was 70 tons; to-day it is nearer 160,000 tons, exclusive of the United States of America. During this time the price has fallen from, roughly, 10s. to about 1s. per pound.

When absolutely pure, aluminium has a white colour and resembles silver; but, as ordinarily seen, it has a bluish or violet tinge, which is said to be partly due to the presence of silicon, and partly to the temperature at which it is cast. When warmed, it softens and can be easily rolled out; in fact, there are only two metals—gold and silver—which exceed it in this respect. Aluminium leaves, such as are used in decorative work, and which, unlike silver, do not blacken on exposure, can be obtained of $\frac{1}{10000}$ inch thick. It can also be drawn into wire, which is useful for electric conductors, the thinnest wire having a diameter of $\frac{1}{250}$ inch. When cast its tensile strength is low—about equal to that of cast-iron; if rolled or hammered when cold it is equal to that of gun-metal, but greater than that of copper. It takes a considerable amount of heat to raise its temperature, and, *per contra*, it cools down very slowly. Its electrical conductivity is 60 per cent. that of the same volume, but double that of the same weight, of copper.

A distinctive feature of aluminium is its lightness; it is about two and a half times as heavy as water, three and a third times lighter than copper, and over seven times lighter than gold. When struck it emits a clear note. Its resisting power to corrosion is great; air and water do not affect it in the least, and hence hundreds of miles of bare aluminium overhead transmission lines have been erected in the United States. The pure metal is unattacked by sea-water, but in contact with other metals it rapidly corrodes, owing to galvanic action. In spite of its great stability towards air and water, it has a very great affinity for oxygen, and if, by amalgamation, we remove the very thin superficial layer of oxide which

A Temperature of 5,400° Fahrenheit

Aluminium mixed with other ingredients is capable of producing the above temperature. The molten mass dropped upon a 1-inch thick steel plate will burn right through it

always coats the metal, it corrodes instantaneously and becomes covered with a white fluffy film of oxide.

An Enormous Temperature

Although it is exceedingly difficult to make aluminium burn, its enormous affinity for oxygen, already referred to, is manifested by a very great disengagement of heat. A crucible made of fireclay and graphite is charged with a mixture of powdered aluminium and red iron ore (iron oxide), and upon this mixture is placed a layer of magnesium filings and a small cartridge made of very combustible materials. The cartridge is lighted with a match, and in a few seconds the whole contents of the crucible are in a state of vigorous eruption. Showers of brilliant sparks are shot out in all directions, and the crucible contents glow with an intense white heat. If the crucible be inclined a molten stream of white-hot iron flows out. The explanation of this volcanic action is that the aluminium robs the iron ore of its oxygen, producing alumina and pure wrought iron. The temperature produced varies with the amount of materials employed, but one of 5,400° F. has been registered.

Although it is far too expensive for reducing iron ores on a large scale, this process has been found very useful for isolating rarer metals like manganese and chromium; also, the high temperature has been utilised for welding iron pipes, steel rails, etc.

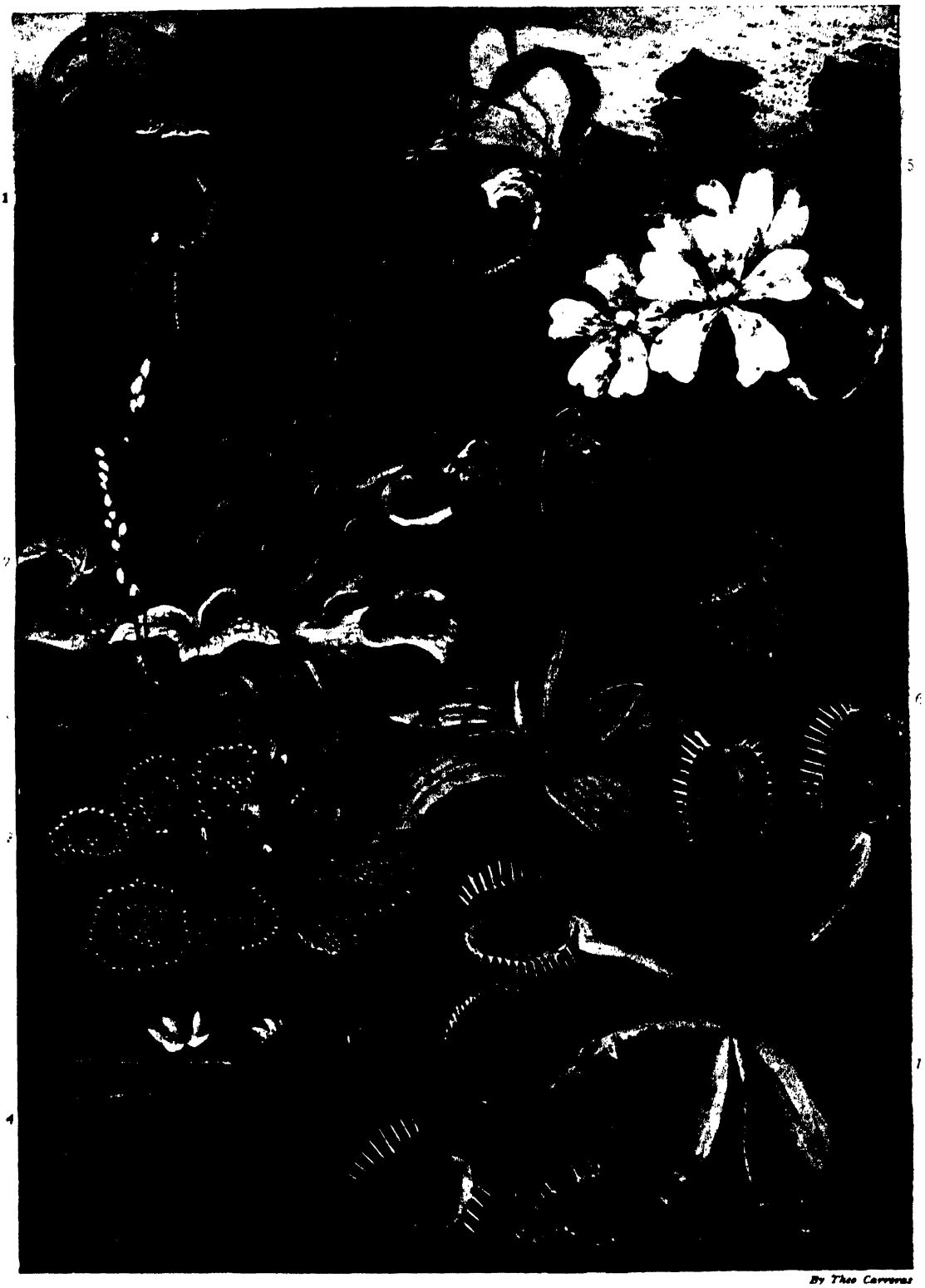
As regards the action of liquids upon this metal, it is only attacked by spirits of salts and by caustic alkalis; hence articles made of it should not be kept too long in soapy water, which contains free alkali. Pure organic acids scarcely affect it, but the action is increased by the presence of common salt. It has been found, however, that after an aluminium saucepan has been in use for some time it becomes coated with a hard, impervious skin which prevents any further dissolution of the metal. Moreover, aluminium and its compounds are quite harmless when taken internally, so that there can never be any question of aluminium poisoning.

Finally, this "silver from clay" has some excellent mechanical properties. It can be cast, rolled, drawn, hammered, filed, forged, annealed, turned and spun on the lathe, polished, welded, soldered, and alloyed. The very first article made of it was a baby's rattle, intended for the infant Prince Imperial in 1856, and, long before it came into general use, the apex of the Washington Monument at Washington was made from a lump which weighed over 100 oz. Since that time the uses have so extended and multiplied that it is impossible to give anything like a complete list.

A New Explosive

Powdered aluminium mixed with oil, forms a cheap and excellent paint, which is particularly valuable for outdoor work. A new explosive, "ammonal," made of the finely powdered metal and nitrate of ammonia, bids fair to make a great name. It is exceedingly powerful, is nearly smokeless, leaves no poisonous gases after explosion, and is absolutely safe to manufacture, to store, and to handle. Last, but not least, are its metallurgical uses. A large portion of the aluminium output is used in foundry work, and some in making steel. The addition of 2 to 5 pounds of aluminium per ton of steel, the moment before casting, serves to remove any air or oxygen the iron may contain, and thus prevents the formation of blow-holes.

Quite a number of aluminium alloys have found their way into use. Of these, one of the best known is aluminium bronze, which contains 90 per cent. of copper and 10 per cent. of aluminium. It has a beautiful golden colour, great strength, and is not corroded by air or sea-water. A somewhat similar alloy used for making imitation gold contains 90 per cent. of copper, 7½ per cent. of aluminium, and only 2½ per cent. of the real precious metal.



By Theo Carreras

A Group of Carnivorous Plants

1. Pitcher Plant (*Nepenthes phyllamphora*)
2. *Sarracenia purpurea*
3. Sundew (*Drosera rotundifolia*)
4. *Aldrovanda vesiculosa*
5. Huntsman's Horn (*Sarracenia*
6. Butterwort (*Utricularia vulgaris*)
7. Venus's Fly-trap (*Dionæa muscipula*)

CARNIVOROUS PLANTS

By S. L. BASTIN

The Gaping Mouth of the Sarracenia

In vain the small insect tries to climb to freedom; presently it will fall from sheer exhaustion into the yawning pitcher beneath

How Meat-Eating Plants Prepare Elaborate Snares to Entrap Birds and Insects

YEARS ago it was the custom to think of plants as quite inoffensive beings, almost entirely at the mercy of the animal creation. This, however, is only one side of the story, for the members of the vegetable kingdom have devised a cunning plan whereby they take a heavy toll of animal life. Amongst plants, no less than with the human race, one of the great problems is to get a sufficient amount of food. Now for their well-being plants must have certain salts, such as nitrogen, potash, etc., and these are not always easy to obtain. Of course, they are generally present in good soil, but in boggy situations there is usually a great deficiency in this respect. In order to meet the difficulty, quite a large number of plants have developed the astonishing habit of catching insects, and even, in some cases, small birds. From the rotting carcasses of the prey the vegetables absorb the much needed nutriment. The ingenuity with which these plants lure their victims on to destruction is simply amazing. Everything is done to tempt the creature to visit the death-traps of the plants, and, on the other hand, no means are spared to make an escape practically impossible.

Some of the most interesting of the carnivorous plants are those which develop pitchers in which to secure their captives. Off-hand, one would think that the possession of pitchers on the part of a plant is only a very small step towards catching any living thing. If a few of these plants are examined it will be seen that they have been clever enough to outwit even the most wily of insects.

Carnivorous Plants

Absorbed in the delights of feasting on the nectar of the Nepenthes, the insect wanders with fatal ease down the fluted rim

Scattered over the tropics of the old world there is a remarkable group of plants known as Nepenthes. Many of these are of a climbing habit, rooting in bark crevices where a little moist soil may have collected. To augment their food supply they have produced pitchers, which in some species are of great size. Indeed, in one kind the receptacles will hold as much as two quarts of water. In all cases these pitchers have a thick corrugated rim, and it is this which plays a big part both in the luring and the capturing of the insects. On this rim, as well as on the lid of the pitcher, there are honey secreting glands, and these, of course, make the strongest appeal to hungry insects. Absorbed in the delights of the feast, the insect wanders with fatal ease down the fluted rim. Once below the inside edge of this, escape is almost impossible, for the border is adorned with sharp, teeth-like processes, all pointing downwards to the pit of destruction. Moreover, the inside walls of the pitcher are specially smoothed with a wax-like secretion, which makes climbing up a very difficult feat. Even insects with wings seem to find a great difficulty in making good their escape.

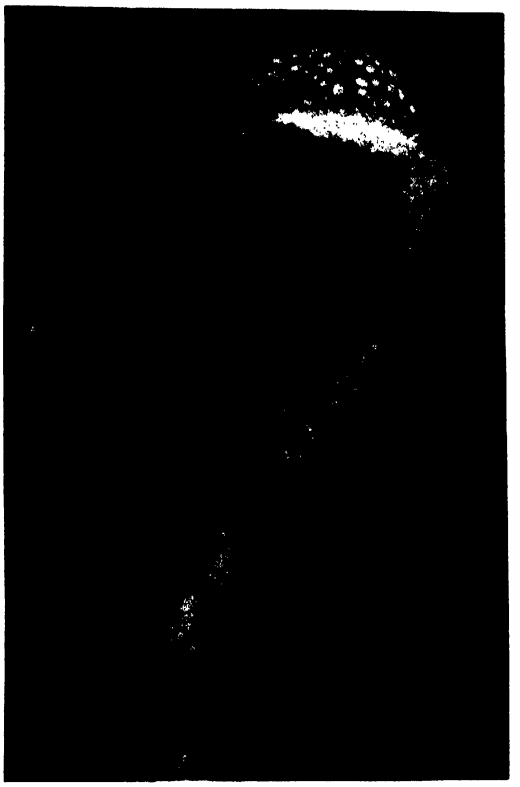
The pitchers of the Nepenthes are usually about half filled with fluid; this is not entirely collected rain or dew, but is largely formed by a definite secretion of the plant. Into this fluid the exhausted insect tumbles sooner or later, there to end miserably amongst a mass of drowning victims. It has been definitely proved that this fluid is an acid secretion—not unlike the digestive juices of an animal—which enables the plant to extract the nutriment it needs from the bodies of its victims.

It is in connection with the fluid contained in the pitchers of the Nepenthes that these plants catch much larger prey than insects. In the tropics it is not

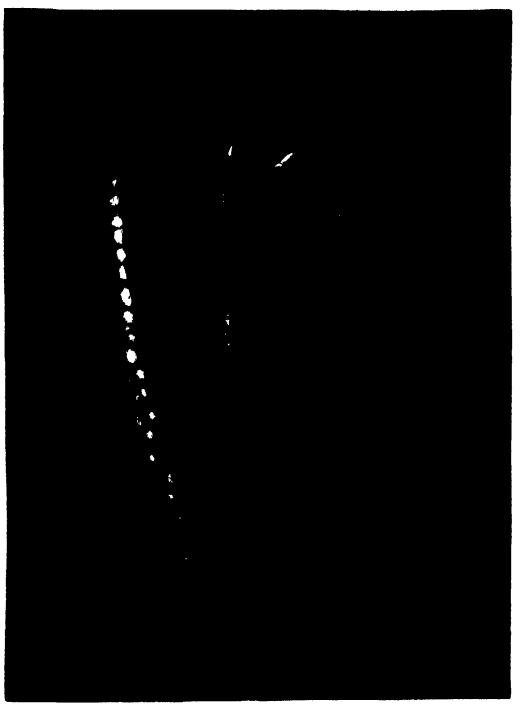
Once below the inside edge, escape is almost impossible. Pitchers have been found wellnigh full of flies and other insects

always an easy matter for birds and other small animals to secure a drink readily. The half-filled pitchers entice many a small creature to creep over the fluted rim in order to secure a draught of the fluid, which is not unpleasant to the taste. Now and again the venturesome visitor loses his hold and tumbles into the pitcher. Even in the case of mice and small birds the pitcher proves a veritable death-trap. The slippery sides are almost insurmountable, whilst the sharp hooks round the rim still further check an escape. Sooner or later the victim falls back into the fluid and is drowned. Strange as it may appear, after such a capture the plant grows vigorously, for the decaying body of its victim is rich in just the food material of which it stands in need.

It is not only in the tropics that we must look for fly-catching pitchers. A very singular group of plants, the Sarracenias, are quite common in the bogs of North America. These are of an elegant

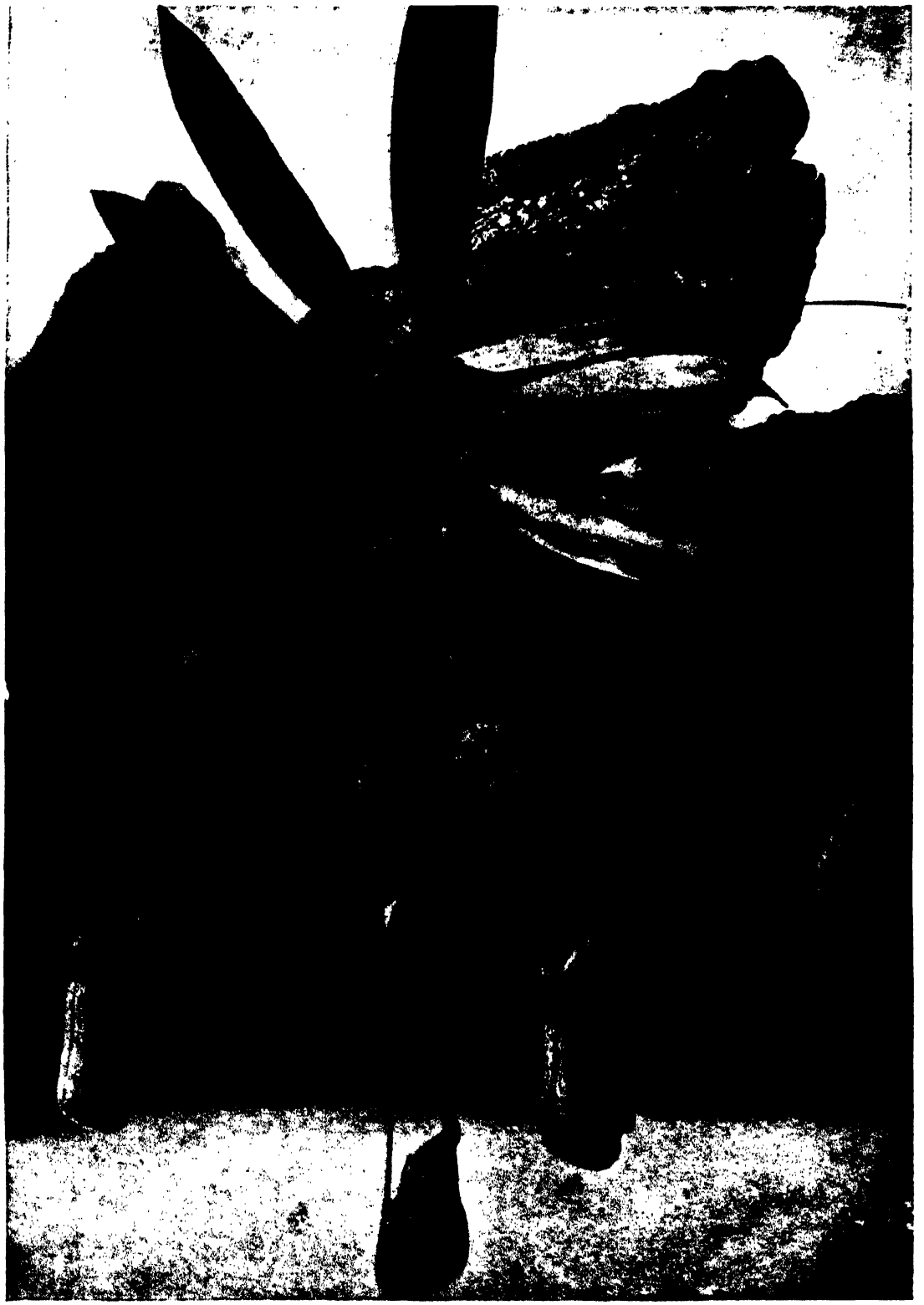


When a fly has entered the Darlingtonia, it is almost impossible to get out again. The lip at the opening is curved inwards like a lobster pot



The light streaming through the transparent spaces induces the prisoner to waste its strength in a vain effort to escape through them

shape, and may be as much as 1 foot or 2 feet in height. Nearly always they are highly coloured, and altogether so attractive do they appear that insects of all kinds simply crowd to them. On arrival at the lip of the pitcher, the insects find a feast of honey spread out for their delectation. With almost devilish ingenuity this becomes sweeter and more plentiful the farther down into the pitcher one traverses. At a certain point, however, the nectar ceases, and the insect thinks that he will retrace his steps. But although it has been easy enough to go down, it is almost impossible to get back, for the surface of the inside of the pitcher is thickly covered with sharp bristles, all pointing downwards into the yawning pit. Some flying insects may escape, but even these do not find it easy, as witness the fact that the plant often catches a large

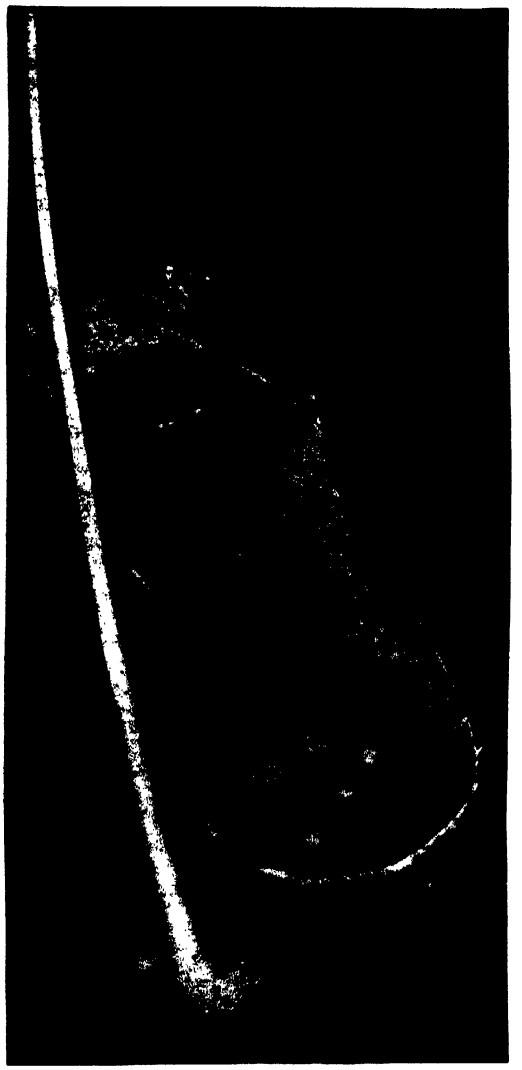


The Nepenthes of Borneo

A typical pitcher plant of a climbing habit, rooting in bark crevices where a little moist soil has collected From this vantage ground the Nepenthes deliberately "fishes" for insects, which it entraps and kills

number of winged creatures. In the lower part of the Sarracenia pitcher a fluid is secreted, and it is into this that the creatures ultimately fall, and of course perish. How successful are the Sarracenias in their insect-catching may be gathered from the fact that pitchers 18 inches or 2 feet in length have been discovered wellnigh full of flies and other small creatures.

A clever Californian plant (Darlingtonia) seems to have been specially devised for the securing of winged creatures. It has been said, and this is probably not far from the truth, that once an insect gets inside the pitcher of a Darlingtonia it never escapes. The plant is most singular in appearance, and the upper part of the pitchers bear a remarkable resemblance to the head of a snake. Part of the hood and also the two protruding leaves are gaily coloured in crimson. It should also be noted that the upper portion of the hood is adorned with transparent patches, like so many little windows. Now, the only opening into the pitcher of the Darlingtonia is quite a small hole on the under side of the hood. As in the case of the other pitcher plants, the orifice of this hole is freely supplied with honey, and this extends well into the interior of the receptacle. Everything is done to tempt the fly to enter the opening, but when once well inside it is almost an impossible feat to get out again. The lip at the opening is curved inwards in such a way that it acts very much like a lobster pot. Owing to the attraction of the little windows, which have been already mentioned, the flies do not attempt to get out of the hole to the extent which might be supposed. The light streaming through the transparent spaces seems to convince the insects that in that direction lies the path to freedom. At all times it is possible to see perhaps a dozen flies bobbing against the windows in a vain endeavour to escape. Finally, wearied to death by their hopeless endeavours to escape, the insects fall down into the lower part of the pitcher and become suffocated by the fluid it contains.



Section of Pitcher of Large Nepenthes
Showing bird that has fallen into the death-trap

A curious little Australian plant which has adopted a very similar plan of fly catching to that to be seen in the Nepenthes is the Cephalotus. One singular feature about this Australian pitcher plant is that it produces quite ordinary leaves in addition to the highly specialised fly-catching ones.

The Hari-kari of a Million Lemmings

The little rodent lemmings colonise a hill-side and multiply so fast that, when the heat of summer scorches the herbage, famine stares them in the face. Then occurs a great migration towards a promised land which they will never reach, for in their headlong course they plunge into the sea and swim boldly oceanwards until the waves engulf them

The Migration of Animals

A Fascinating Mystery of Past and Present
When Britain had her Lions and Tigers and Britons Chased the Mammoth

By N. F. WATSON

THE finest zoological collection in the world is that of London. There has been a finer. That, too, was British. To be more exact, it was the great natural Zoo which roamed free, wild and gigantic over what the world now knows as Britain. The land was, in fact, the westernmost extension of Europe, or the most easterly fringe of North America.

Had the camel arrived at perfection in time, he might have walked dry-foot from his cradle in America to Britain, as the horse possibly did. He reached India and northern Africa, leaving behind a relic of his former outline in the llama, alpaca, and guanaco of the Andes and lower levels of the South American continent, but the way to Europe was closed when the camel was warned to move on.

There was not much else of the early fauna that failed to find us. We had representatives of the terrific reptile monsters, the dragons of the prime, which ruled the earth and possessed it. We find in our cliffs and sea-walls the skeletons of whales larger than any whose dimensions are to-day authenticated. We had the mighty primitive cave lion; we had cave bears half as large again as any known to-day—unless the Alaskan giants of the tribe may be regarded as rivals to the ancient terrors of the caverns. Hyenas fought with our savage ancestors for the shelter of the caves and for the bones of other animals slain by both in the chase. The greatest thing in tigers, the sabre-toothed horror, had its home in un-merry England, and the mammoth, lord of elephants, shook our British soil with its ponderous tread and floundered into the pitfalls dug by the wiles of our painted, flint-slinging forbears.

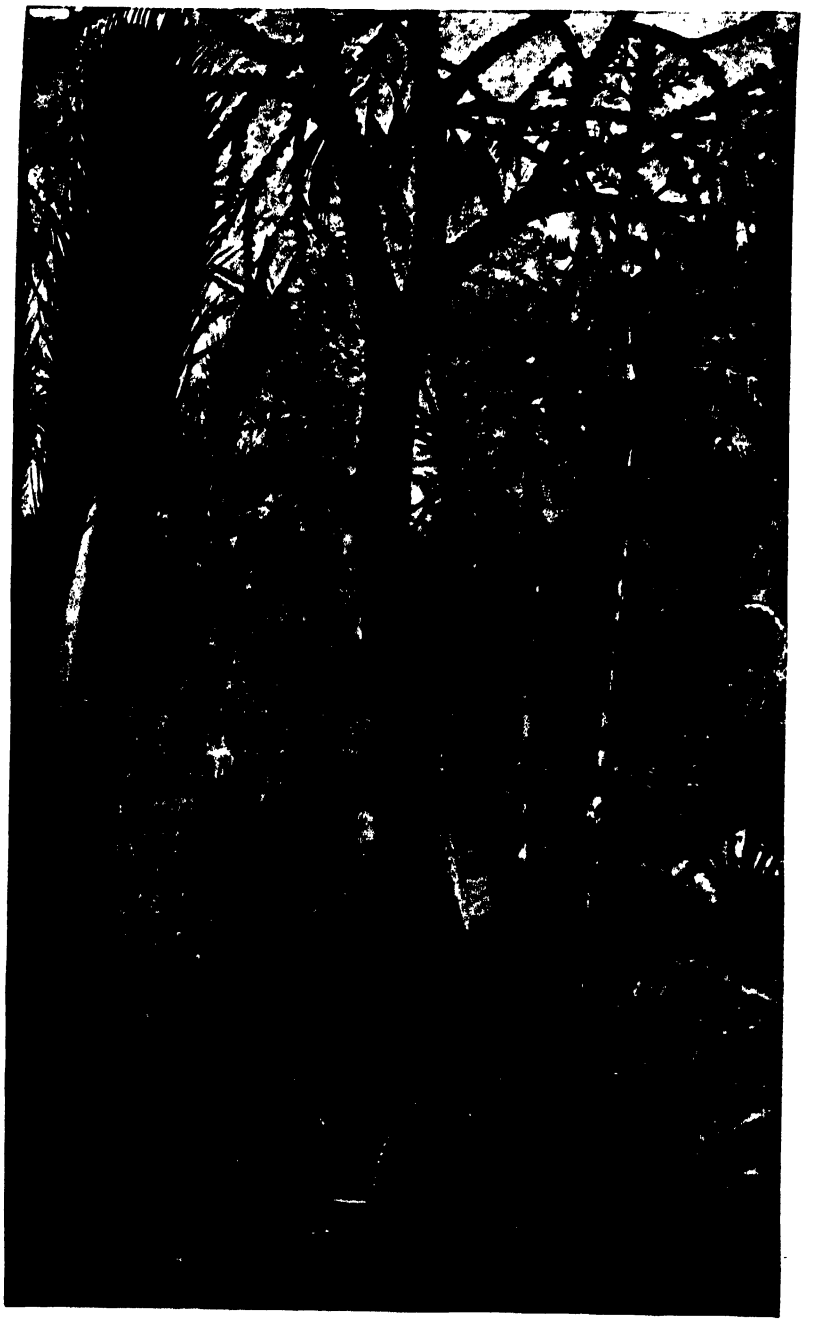
Our Early Fauna

All this is suggestive of a rich and tropical vegetation—such, indeed, as we should expect to find in a land so abundantly blessed in the matter of coal the vegetation of geology's yesterday. If further evidence on the point were needed, the remains of hosts of departed rhinoceroses, which were British before the earliest Britons; of heat-loving giants, such as crocodiles and alligators; of tapirs, now restricted to two parts of the world alone; of monkeys; of racoons, leopards, pikas; of African elephants, hippopotami—these attest the existence of a vegetation such as we now find associated with tropical or sub-tropical lands.

Geology's Yesterday

America could not send us a camel, but she may have given us the horse, or, on the other hand, this friend of man may have come to us from Europe. But undoubtedly she gave us animals of a type able to withstand the rigors of our climate, for we had our days of whited silence, our glacial age, 150,000 years in duration, ending, as far as we can calculate, some 50,000 years ago. And in that epoch there came to us, and flourished abundantly, the musk ox, reindeer, and titanic elk. Man, it is believed, was here to see it, to warm his hands at the first of fires, and to keep life within him by feasting upon the flesh of the mammoth and other big flesh carriers. Perhaps the

chase of mammoth and elk and reindeer and horse may have brought him here. Old cave drawings and pictures worked with flint upon bone and ivory, limned by prehistoric man, preserve for us some of the tableaux of those hunting days in the dawn of the world's history; and from these we get a good idea of his battles with the brutes, whose inferior he was, of course, in all but brain power.



Former Denizens of Britain

Among the luxurious tropical vegetation of Britain's Carboniferous era there moved heat-loving giants, whose skeletons remain to-day

Whence, then, came this mighty array of animals of various climes and habits, and whither went they? Here we are, a little group of islands set in the sea, insulated from the rest of the world, so that to get a dry way to the Continent we are preparing afresh to burrow, under the Channel. Our prehistoric fauna had no such advantage as that proposed to be conferred upon the present generation.

When the animals were lords of creation they colonised us from the New World, as, within the last few centuries, the Old World has colonised the New. But they were not mariners. They travelled afoot. Nature's prodigal sons, in that far-away age, asked for no patrimony; but they journeyed into distant lands by routes which are now open only to water transport. Land connections existed between all the continents.

This is not to say that where wide, deep oceans now roll their troubled waters, dry land once stood. The oceans are too deep for the old conception of the earth's history to be true. The modern student does not believe that ocean depths of 20,000 or 30,000 feet, ever, within the time of life upon the globe, knew the existence of dry land. The oceans are and have been permanent; they stretch now pretty much where they have been from time immemorial. The route of the liners to America was never the route of travelling animals. The track did not lie that way. The old land connections existed in the form of land bridges, connecting the continents in high latitudes. The Arctic was once a green and thriving region. There lay the path, bestrewn with luxurious vegetation, and that way lay the route of the migrants. We are not to suppose that monkeys and mammoths set out from America, to "see Europe," in the manner of their human successors in the land of the free, or that European-born fauna travelled post to America. They spread out beyond their several birthplaces, just as plants grow out into new areas. Thus, denizens of the Old World wandered on, new tract after new tract conquered in successive ages, until the fauna of Orient and Occident became in many particulars identical. Not in all, for, while animal families, many in number, were being slowly evolved from the few, so changes of corresponding magnitude crept over the face of the earth.

Ancient Land Bridges

The effect of the process is seen in areas so nearly related, in a geographical sense, as Madagascar and the adjacent coast of Africa. The fauna of the island is totally distinct from that of the continent of which it once formed part.

The reason for this is that Madagascar was suddenly cut off from its motherland by a sinkage of the bridge by which it had been connected. The severance came at a time when the fauna of Africa was but little developed. Madagascar had, at that time, types of such animals as Africa possessed. These, suddenly shut up in an island, developed upon different lines from those free to roam and intermix with a great generalised group on the continent. There was no entry into the island for the newer, more highly developed, types of which Africa later became the home; there was no escape for those already marooned. The animal Crusoes of Madagascar, unvexed by the keen competition which we know as the struggle for existence, remained primitive and strange in character, whereas those of the motherland became highly developed by constant additions to their ranks, from lands to which bridges still existed.

Similarly, Malta and Cyprus received a contingent of African elephants which, like the ponies of our Shetland islands, became dwarfed by environment, and died out as animals no greater in bulk than good-sized sheep.

Australasia is, of course, the best example of the point. It had long been surmised that there formerly existed a connection between Australia and other lands, and the Scott expedition to the Antarctic has made it clear that Australia and South America were anciently associated in this manner. The great island continent received her animals at an age in which the mammal type was of the most primitive character. They had reached her from South America, where, later, such monstrosities were to develop to stagger creation, and then mysteriously to disappear from the book of the living.

Australia, with her marsupials and her furred and spiny, warm-blooded animals which lay eggs, was suddenly insulated with a menagerie of animals, among the best then available, but occupying a place which to-day is the lowest in the scale of mammalian creation. She improved

Strange Australian Types

upon the model, and cultivated creatures huge as oxen, but invented no new type. The sister island, New Zealand, a thousand miles away, must have been cut off still earlier, for she was left with nothing bigger than a bat or two, a handful of insects, and some strange birds and lizards. With the severance of material ties with the rest of the world disappeared Australasia's hope of a fauna resembling that which arose in other parts of the globe.

When thus insulated Australasia had the marsupial, as America has to-day in the opossums. The best she could make of the brand was a tribe of animals of all sizes, from the minute mouse to the giant kangaroo, whose young are born in so immature a condition that their nourishment has to be continued within the external pouch of the mother, where the helpless, unformed young grow like cuttings grafted upon a tree. Also she produced, or fostered, the two egg-laying mammals mentioned—the platypus, an animal with the webbed feet of a sort of water mole, the beak of a duck, and the fur of a beaver, which animal lays actual eggs and broods them in its burrow as a bird broods its eggs in a nest; and the echidna or spiny ant-eater, which, after laying its eggs, places them in a marsupial pouch and there hatches them, much as some of the frogs hatch theirs.

With Britain, however, the case was different. Animals migrated to us and away, for, though we live upon a mountain whose broad base is set in the sea, we have had many literal ups and downs in the water above it and below. We have been an outlying part of America, connected with that continent by land tracks running through Greenland. When that condition prevailed there were temperate, even sub-tropical, conditions, in the Arctic. The Arctic to-day merely reproduces the conditions of the worst era of our own Glacial Age; that is all. In happier days it produced a generous food supply for herb-eating animals, and the path from America to England lay, not across the trackless waste of waters, but by a way marked out by abundant verdure, through what is now the Arctic zone.

British Ups and Downs

We have also been an integral part of Europe, and that more than once. If ever a World Congress determined to restore ancient boundaries, and had power to give effect to its determination, the English Channel and the Irish Sea would be swept back, the land would be slightly raised, and we should find ourselves again part of Europe. The British Isles would be one with Europe, whose true boundary lies fifty miles west of the west coast of Ireland. It was formerly all dry land. The English Channel was simply a river valley. The spire of an average church steeple would rise above the waves in any part of the English Channel even to-day.

Britain no Island

If there should come some day an uprising of land of merely 20 fathoms, England and Ireland would become, as they were before, joined to France, Holland, and Denmark. So narrow is the margin of safety that a sinkage of our land to the extent of only 100 feet, would result in the submersion of a great part of London, Liverpool, Bristol, Newcastle, Hull, Cardiff, Southampton, Portsmouth, Chichester, and other places of corresponding elevation, and, as the late Lord Avebury showed, carry the sea right into the heart of the country, where whales and sharks and dolphins would take the place of industrious citizens.

Now, the dippings and risings, which geological action brought about in the old days, gave us from time to time great additions to our fauna. We were connected by land with Europe and Asia, through Europe with Africa, and again, with America. Great families of strange beasts, arising in the Old World and the New, obeying the mandate to be fruitful and multiply, spread out afar from their cradles.

A Tragedy of Primeval Days

Drawn by Hiram Roger

Sometimes the conditions of the ground over which mammoths and other mighty migrating animals passed brought them to untimely death, bogged in yielding mud and frozen there, or torn to pieces by hyenas

Migration of Animals

Drawn by S. Rose, from material supplied by Mrs. Hubbard

A Living Bridge of 3,000 Migrating Caribou

from the place in which a species had arisen and become a fixed type. They reached England from West and East. It was a wonderful collection all told.

To-day we find the tapir only in tropical America and in Malaya, yet we find them abundantly represented in the fossil deposits of England. They overspread the temperate world from China to Charing Cross, but disaster inexplicable blotted them out in all but the parts named. The camels wandered from their home in the New World to Arabia and to the chilly wastes of Mongolia, where, if anywhere, the last of the wild stock remains. Ancestors of the horse roamed between America and Europe, so that we do not know which originated first. They attained perfect, though not identical, development in both continents yet, by one of those inscrutable mysteries which apply to so many sealed volumes of the history of animals, all suddenly vanished out of the western land, whether from famine or from some such

epidemic as we have seen raging among animals in Africa, or from the effect of poison-bearing insects, or from the rigors of a changed climate, we know not. Certainly, when the Spaniards reached America, there was not a horse in the land.

The Home of the Elephant

Africa gave us the members of the elephant tribe, whose bones are dug up from time to time in London and various parts of the south of England. They originated, it has recently been discovered, in the Fayum Valley, in Middle Egypt, at a time when Africa was isolated by seas from the rest of the world. Unable to migrate to new conditions in which enforced development upon other lines must have resulted, they evolved from small pig-like animals resembling the tapir, which, formerly indigenous here, comes back to us now, after all these hundreds of thousands of years, to eat titbits from our hands at the Zoo. When communication between Africa and the rest of the world was re-established by the raising of the sea floor near her coasts, the elephant tribe had attained to gigantic dimensions, and with power and thrustfulness they rapidly overran both East and West, travelling through Europe and Asia and America, to branch out into distinct types, such as the mastodon and mammoth, with which Neolithic man fought and with which he stored his larder for the hyena to rob. The hippopotamus and the woolly rhinoceros came to us from Africa, and these, too, were among the quarry of the first big game hunters.

Sometimes the conditions of the ground over which these mighty animals travelled brought them to death, and to-day, from time to time, the thawing of a Russian or Siberian river reveals to us the interned carcass of some giant of other days which came to an untimely death, bogged in yielding mud and frozen there.

What cause led to the extermination of the mammoth in our land we cannot know. Man played his share; doubtless changing climate and consequent modification of food supply had much to do with it. One high authority attributes the downfall of the elephant tribe, except in the more favourable parts of Africa and Asia, to the rise of the mighty carnivores, such as the giant sabre-toothed tiger, whose awe-inspiring remains are among the most grim, if precious, relics of those riving days in Britain's murky past.

As to the probable reason for the disappearance of some other of our natives, there need be less doubt. The climatic changes experienced sufficed for the obliteration of many. This land, which afforded a generous livelihood to the Arctic reindeer, long sheltered the warmth-loving monkey of Africa and all the members of the crocodile family. There is a remarkable fact to be noted in connection with the latter group. To-day, if the menagerist would build up a representative reptilian collection, he must scour three continents. He must seek the dreaded gharial in the warm rivers of India; he must pass west to the waters of tropical America for his alligators, and must proceed thence to Africa for other members of the tribe. Neither gharial nor alligator is to be found in Africa. Yet, in the days of tropical England, every member of the crocodile family raised its voice in the hoarse, bellowing chorus with which the marshy wastes resounded in the area over which Bow Church now rings out its bells.

Tropical Luxuriance

It is unnecessary to go back to the great age of reptiles, to the dinosaurs, the fish lizards, and what not, to emphasise the point as to the heat, the climate, and the tropical luxuriance of the conditions. Our Ice Age swept out the unfit, as the term is understood in high latitudes, and accounted, we are to suppose, for the disappearance of the hippopotamus. This animal found its way to York before the Romans, by some few score thousand

years. Some hold that this animal used to travel north during our glacial summers. But this is highly unlikely.

Our Ice Age

Our Ice Age began, we are taught to suppose, 200,000 years ago, and ended 150,000 years later. But modern research shows that the Ice Age was not without intermission. It was broken up into several periods, following one upon another, after intervals of temperate climate. If the hippopotamus extended his English travels over any considerable period of that epoch, it would, in all likelihood, be during the warmer interludes, which may have covered centuries or thousands of years at a time. Many animals, erroneously regarded as wedded to tropical conditions, will go up to the mountain snow-line; but we can hardly fancy the hippopotamus leaving the steaming warmth of his weedy river to seek the mountain's snowy crown.

But sabre-toothed tiger and woolly rhinoceros are one with the English crocodile, the mammoth, and the dinosaurs. We know whence they came, we cannot say whither they went, nor how. They may have been able to retreat by some remote land-bridge to America, others to the warmer lands calling in the East.

There is a mysterious instinct in the lower orders which impels them at times to migrate. Vast roads exist still across the American prairies, where the countless hordes of bison once made their yearly marches. The sight of a company of African antelopes on their annual migration in search of water and unsullied vegetation has been described a hundred times. An illustration shows a herd of migrating caribou as seen by an eye-witness.

But the greatest wonder of the kind is, of course, the migration of the little rodent lemmings. These colonise a hill-side and multiply as only small animals of this character can. The tiny colony becomes a city, and the city a province, all its citizens lemmings. An early favourable spring brings prosperity to a climax. With abundant early food the community multiplies at such an amazing rate that, when the heat of summer comes to scorch the herbage, uncompromising starvation stares the millions in the face; and together, with one consent, after some few days of commotion and apparent consultation, the whole army, millions and millions strong, pours headlong from its capital. It flows in a straight line, a surging torrent of life, through fields and gardens, through cities, villages, and towns—a torrent which nothing can divert. Predaceous birds and animals hover on the flanks of the fleeing army, devouring thousands on the march; thousands more die of starvation or injuries, but still the frantic stampede continues, straight on, relentlessly, to death.

The Lemmings' Fate

The mad, scurrying army, with frenzied energy, presses forward to its doom, halting nowhere until the sea is reached. And there the survivors plunge in, not deliberately to suicide, but because instinct still impels them forward to some promised land which they will never reach. Millions of corpses strew the line of march, millions more dot the waves of the sea which has received them.

Is it not within the bounds of possibility that vast changes in ancient days may sometimes have hounded our monsters on to some such pilgrimage of death; to flee from the impending wrath of advancing glacier; from the coming of a winter fated to last longer than the present age of the human race; to fly from a stricken land, only to find a grave in the deep, such as awaits the march of every lemming colony which periodically sets its myriad members upon the tramp to doom? That is the unlikeliest of all suggested causes; but it may conceivably have contributed to the staggering story which the fossil remains tell us of enormous catastrophes that overtook the animal race when all the world was younger.

The Rock-hewn City of Petra

Some of the Most Wonderful Ruins in the World

By H. J. SHEPSTONE

ON the north-west edge of the great Arabian desert, about midway between the Gulf of Akabah and the Dead Sea, among the desolate mountains, stand the remains of the rock-hewn city of Petra, some of the most wonderful ruins in the world.

Other ruins, such as Palmyra and Baalbec, how crumbling piles of magnificent architectural monuments, but in Petra, high up among the mountains that sentinel it, are temples, theatres, tombs, and other structures, strong and indestructible, standing almost as perfect as when they were chiselled out of the living rock of which they still form a part. They challenge admiration by the variety of styles they embody, and by the exquisite hues of the sandstone from which they are hewn, varying from the prevailing purplish-red of the mountains and cliffs to a delicate pink and rose.

Until quite recently, this ancient city built out of rocks was seldom visited and almost unknown. Now, however, by means of the new Damascus to Mecca Railway, they are within reach of civilisation. A fifteen hours' journey from Jerusalem brings one to Ziza, from which place train can be taken to Maan, the railway ride occupying about seven hours. From the latter place the ruins can be reached in six to eight hours by horseback.

The rock-hewn city is approached through a narrow gorge called the Sik. At one place the ravine opens out to roughly two miles in width for a distance of about a mile, and here, protected by mountains and precipices on every side, the people of this remarkable town felt secure from attack from without. Owing to its impregnable position, and its proximity to the great caravan route to the Red Sea from the north, Petra was formerly important as a trading centre and stopping place.

After traversing the narrow gorge for

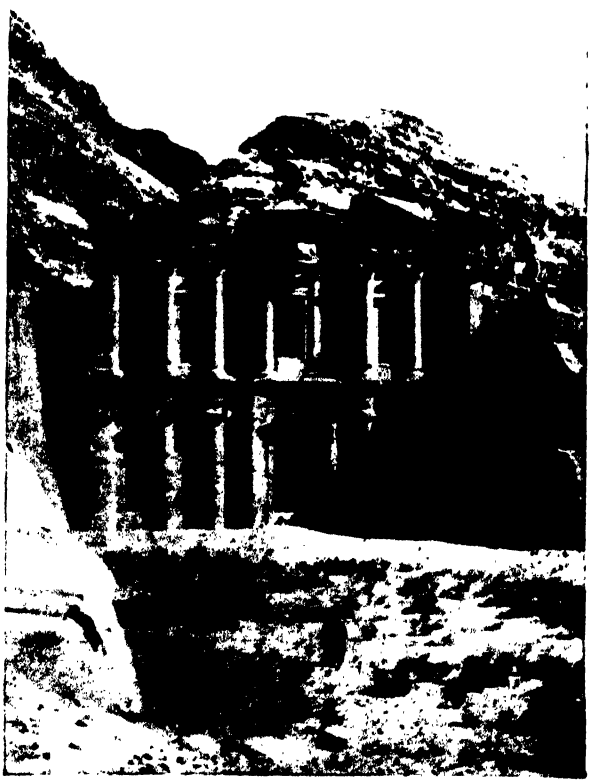


Photo: American Colony, Jerusalem

The Temple of El Deir

Dedicated to the worship of Dusharah, the deified king of the Nabatæans—500 feet above the city

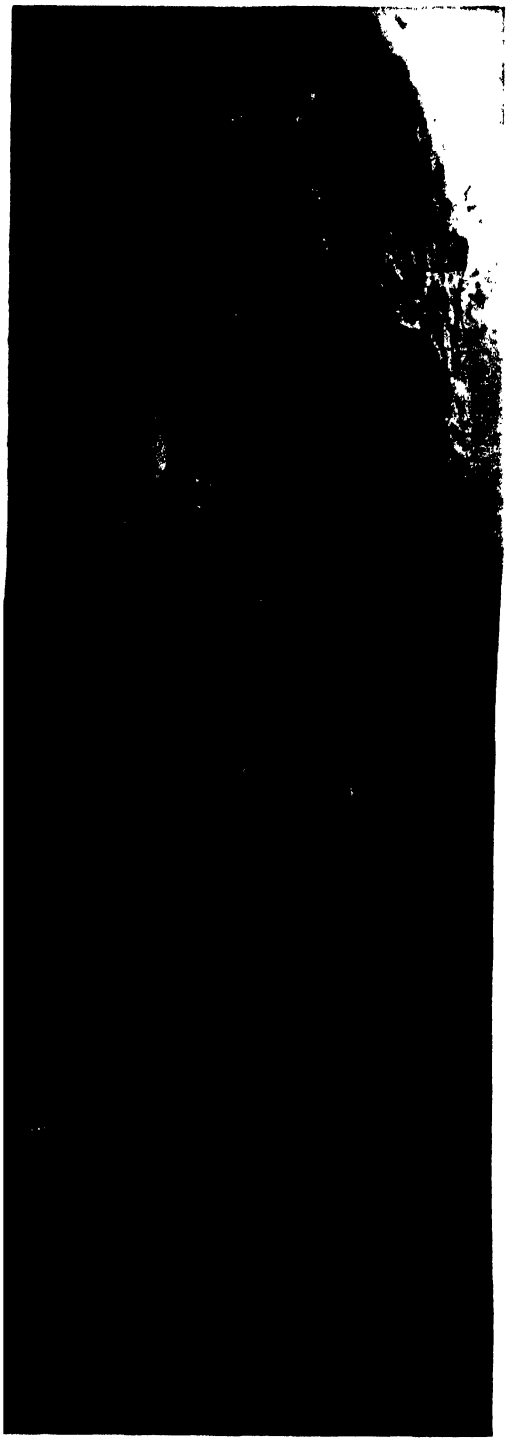


Photo: American Colony, Jerusalem

The Treasury of Pharaoh

This wonder of the East, attributed to Hadrian, is hewn from a rock wall of an exquisite rose-pink colour

some twenty minutes, one is confronted with that famous monument, the Khaznet el Firaun, or Treasury of Pharaoh, which is rightly regarded as one of the wonders of the East. It is attributed to the Emperor Hadrian, who visited the place in A.D. 131, and erected here a temple to Isis. The rock wall from which it is hewn is an exquisite rose-pink. It is in a state of remarkable preservation. The imposing façade shows two rows each of six majestic columns, one row above the other, with niches in which are rock-hewn equestrian and other statues, the whole terminating above in a miniature temple crowned by a huge urn, the entire height being 102 feet. Within is a bare lofty room and some chambers. The urn is said to contain treasures of Pharaoh.

A short distance beyond one emerges into the mountain-guarded valley in which the city lay, mounds of debris marking the sites of the former homes of the Petrans. The rock-hewn structures, chiselled in the precipitous cliffs on every side, were public buildings and tombs rather than dwellings. Just on the left, as the valley is entered, is the vast rock-cut theatre in semi-circular form, capable of holding 3,000 spectators, the workmanship of which is Greek. There are thirty-three tiers of seats. Another wonderful ruin here is that known as the Kasr Firaun, or Castle of Pharaoh. It may have been used as a temple, as it contains an altar.

Some of the structures are close to the ground, while others are high up among the cliffs, and only reached by climbing the winding staircases that lead up to them.

A rock-hewn stairway of many hundreds of steps brings one to the largest of Petra's ruins, the El Deir, or Convent. In design it somewhat resembles the Treasury of Pharaoh. It is nearly 150 feet long, and almost as high, having a double row of six columns each, adorned with corner pilasters on both sides and on both storeys. Natives declare that in the dead of night

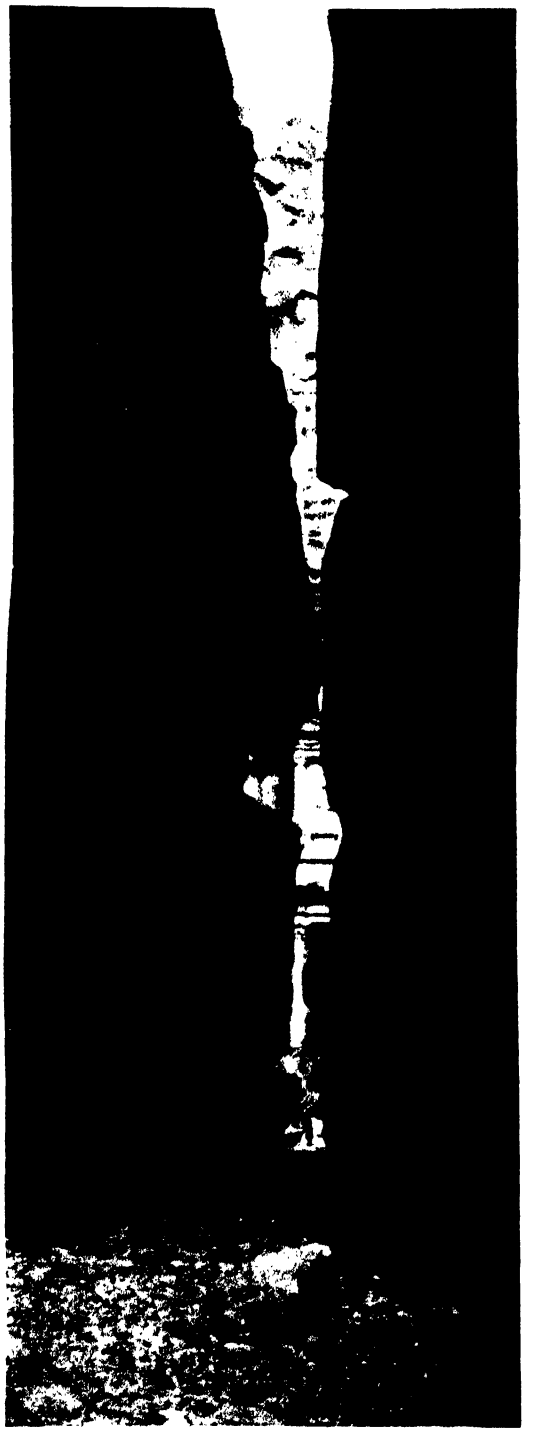
the growls of the hyenas and other wild beasts may be heard within its chambers.

The cliffs that enclose the valley are simply dotted all over with the handiwork of artists of a bygone age. Here is a portion of a heathen temple, there the remains of a palace, yonder a column, and beyond, again, a stately portico or pediment. They stand at varying elevations. Most of them are conspicuous, while others are hidden in the mountain recesses. There are tombs by the hundred, and on the mountain tops many places of sacrifice, where strange religious ceremonies were enacted.

Indeed, it was not until Petra was explored that the meaning of the oft-repeated Bible reference to the "high place" was understood. Here thousands upon thousands of stairs lead up over dizzying boulders to the summit, where was situated the high place, with its altars, pool, and court—the place of sacrifice.

Of tombs, no fewer than eight hundred have been located, all hewn out of the solid rock, and many adorned with magnificent monuments. Some of them were built by the warlike Nabataeans, and others by the Romans and Greeks. The latter are decidedly the more interesting, being, in some instances, very massive and elaborate affairs. There is the Tomb with the Urn, the Corinthian Tomb, the Tomb with the Three Storeys, the Tomb of the Governor, and a host of others. The first-named is a two-storey structure, containing ten vaults, now empty. These chambers, the largest of which is 60 feet square, are filled with tomb niches. The Tomb of the Governor marks the resting-place of Sextus Florentinus, one of the Roman Governors of Petra.

One of the most impressive features of the place is the innumerable steps that lead up the steep mountain-sides, every one hewn out of the solid rock. Then down through this valley a river flowed, though it is now dry. You can still see where it was bridged, and here and there the



A Strait and Narrow Gate

Petra stands in a ravine two miles in width, which can only be reached by way of a long, narrow, and easily-defended gorge

roadway widened by cutting away the foot of the rock. Perhaps the ingenuity and indefatigable energy of the dwellers of this ancient city is best shown in the huge tunnel they cut through the mountain, at the opening of the Sik or gorge, whereby they could in winter divert to the other side of their mountain the winter torrent, which has since that day brought down boulders weighing many tons. This tunnel was come into possession of the warlike Nabataeans, descendants of Nebaioth, the eldest son of Ishmael, who made it their capital, and it was known to the Greeks as Petra. Strabo, the Greek traveller and historian, describes it at the end of the last century B.C., as also did Pliny, the Roman writer, in the first century of our era. In 105 A.D. it passed under Roman rule.

It continued populous and prosperous

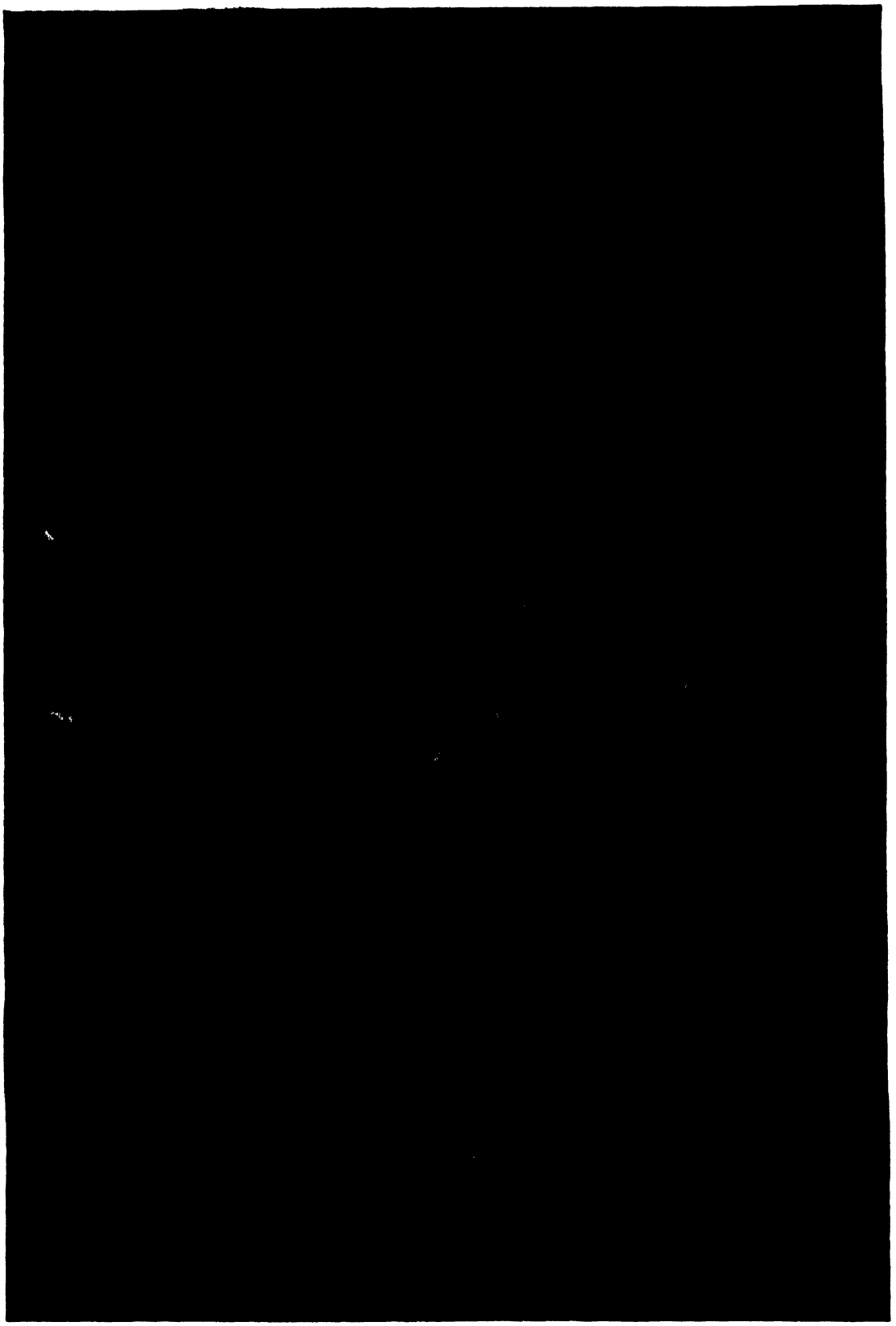
Photo American Colony, Jerusalem

Three-storeyed Tomb or Temple at Petra

Petra was probably the capital of Edom. The conquest of the latter is related in the Old Testament

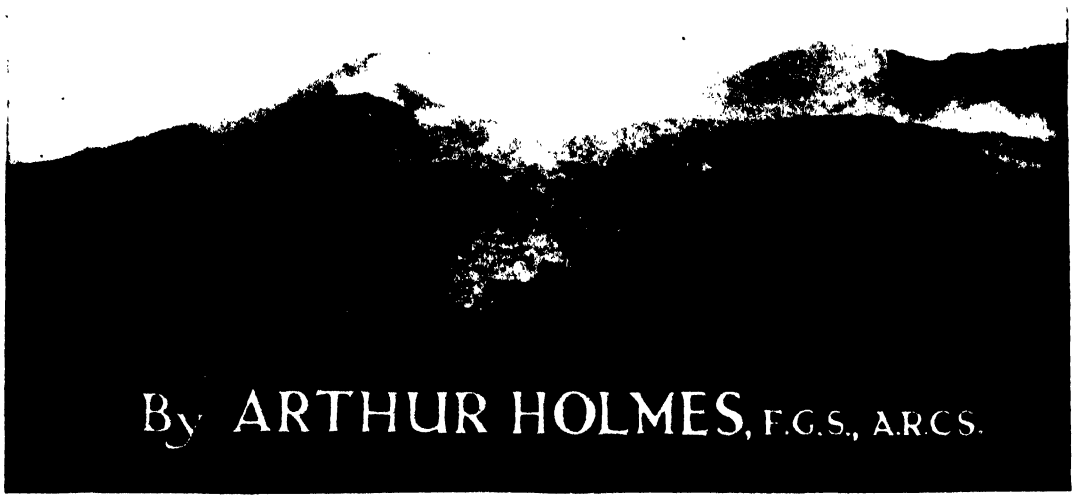
16½ feet broad, 19½ feet high, and 330 feet long. One can also trace the course of the aqueducts which brought the drinking-water into Petra, as well as the grand arch or portal thrown across the entrance to the city.

What of the people who dwelt in this city? And why did they desert it? In its palmy days it is estimated to have had a population of from 40,000 to 80,000 souls. Its early history is hidden in the mists of antiquity, though it was probably the capital of Edom, and is possibly referred to in 2 Kings xiv. 7. About 300 B.C. it had as a trade depot until about the beginning of the fourth century, when the caravan route from the north, which had for so many centuries led past its portal to the Red Sea, was diverted to the Persian Gulf. After this it rapidly declined, and it is not heard of again until about A.D. 536. Even its very existence and site were forgotten, until it was visited and identified by Seetzen in 1807, and explored and described by Burckhardt in 1812. The latter succeeded in gaining access to it, as he did also to Mecca, by the dangerous expedient of disguising himself as a Moslem pilgrim.



The Eruption of Krakatoa

VOLCANOES—II



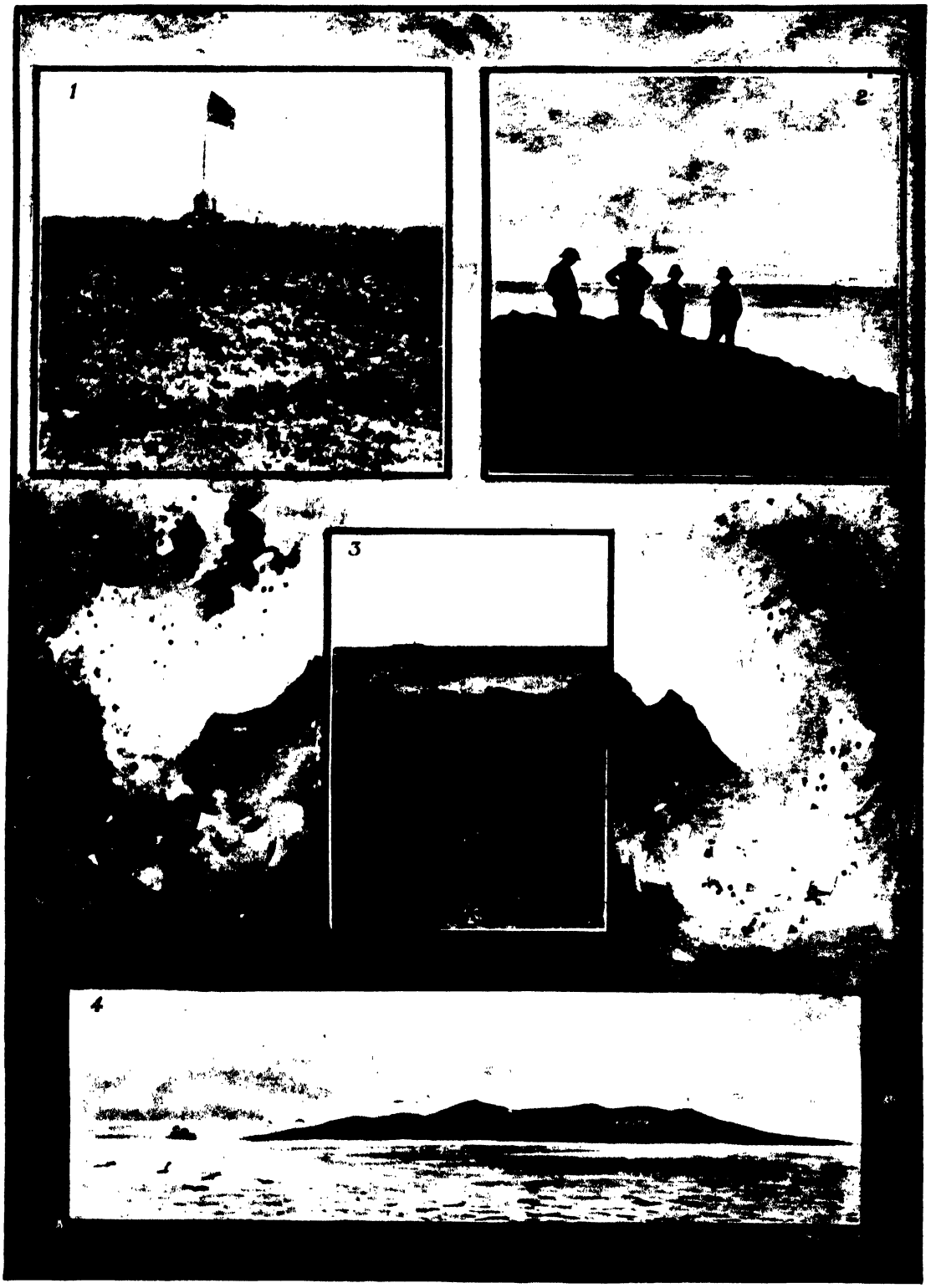
By ARTHUR HOLMES, F.G.S., A.R.C.S.

Submarine Vulcanism—How Islands are Born in a Night and may Disappear as Quickly

THE terrible eruption of Pelée in 1902, described in a previous article on Volcanoes, an appalling catastrophe in which the ill-fated city of St. Pierre was utterly blotted out, recalls in many of its details the classical outburst of Vesuvius in the year 79 A.D. Vesuvius began as a submarine volcano, and built up a foundation of ashes and lava 600 feet thick before it raised its active vents above the sea. It then built up by successive flows of lava and showers of ashes the old crater of Monte Somma. At the beginning of the Christian era the volcano was dormant, and so long had it slumbered that no tradition of its activity had survived. The scoriæ and lava of the sides and crater were hidden by a luxuriant vegetation, which had flourished undisturbed for centuries. In 63 came the first warning, a severe earthquake which damaged many of the temples and palaces of Pompeii. For sixteen years the premonitory warnings continued. At last, in 79, the imprisoned forces were liberated. The dense black clouds, the terrifying detonations, the swaying of the ground, the eccentric rise and fall of the sea, all began their homicidal work. Herculaneum was overwhelmed in a stifling torrent of hot mud, and Pompeii was buried in suffocating ashes and cinders.

The eruption blew out the seaward portion of the old crater, and within it rose the new cone of Vesuvius. Since then eruption after eruption has added its tribute to the forces within the earth. Great lava floods have swept the sides of the mountain; cones have been raised and destroyed again and again, and a great outburst, repeating the horrors of the Pompeii disaster, occurred as recently as 1906.

Space will not allow us to enter into a description of all the innumerable phases of vulcanism. Every volcano is a law unto itself; Stromboli, with its curling puffs of vapour, constantly engaged in a gentle display of activity, which has earned



Photos and drawing by Lieutenant E. T. Headlam

The Birth of a Volcanic Island on Dec. 15, 1906, off Burma

1. The Marine Survey of India hoisting a warning flag on the New Island, which was 400 yards long and 200 yards broad. 2. Officers of the Marine Survey watching the liquid mud exuding from a small active crater. 3. A small active crater of liquid mud; in the distance the Royal Indian Marine ship *Investigator* 4. The general appearance of the New Island, due to the eruption of a mud volcano, at a distance of half a mile. When the survey party landed, the mud, at a depth of 3 feet, registered 148 degrees Fahrenheit

for it the title of "the lighthouse of the Mediterranean"; Monte Nuovo, a cone of ashes, which was built up in three days as the result of an isolated eruption in 1538; the Hawaiian volcanoes, with their great pools of molten basalt. All of these and many more deserve mention, but we must pass on and briefly consider submarine volcanoes.

The great mountain peaks which rise from the ocean floor, whether their crests remain submerged beneath the waves, or whether they proudly raise their rugged heads into the sunshine as oceanic islands, are almost all of volcanic origin. There can be no doubt that submarine eruptions frequently take place from craters opened out in the bed of the oceans, for, from time to time, reports are logged of curious phenomena which can be explained in no other way. Suddenly the surface of the water becomes violently agitated and appears to boil. Long jets of spray are explosively thrown out accompanied by dense vapours and flaming gases. The configuration of the sea floor is totally changed after a commotion of this kind, and great quantities of ashes and pumice float over the scene of the disturbance.

Sometimes, however, a more startling proof of submarine vulcanism is afforded by the sudden appearance of a rocky island where previously the surface of the waters was unbroken. The most renowned example of this unforeseen creation of land is that of Graham's Island, which was cast up in the Mediterranean during the summer of 1831. Where previously the sea had a depth of 600 feet, an island arose to a height of 200 feet. Severe earthquake shocks were felt by passing ships towards the end of June. The next month saw the birth of the new island as a tiny, but active, crater, bathed in a perpetual fog generated by the boiling waters all around. It continued to grow until the beginning of August. Then however, this ephemeral island began to fall away. Attacked by the ceaseless bombardment of the waves, its fragile materials were easily loosened and carried away till, after a few months it was worn down to a submarine bank, and the sea reigned once more in its place.

"The Lighthouse of the Mediterranean"

Stromboli, with its curling puffs of vapour, is constantly engaged in a gentle display of activity

Leaving the spectacular phases of volcanic phenomena, let us now turn to the underlying causes which lead to the expulsion of material from the earth's interior.

The first of the extraordinary elements involved in vulcanism to be explained is the source and origin of the magmas, or molten rocks. One of the earliest views was that, as the earth grows hotter from the surface downwards, the interior, at a depth of, say, thirty miles, must be in a molten condition. A volcano would then be a pipe leading down to the molten mass within. There are, however, fatal

A Sectional View of a Volcano, showing Supply Basin of Lava

Lavas are due to the local fusion of deep-seated rocks. The materials most easily fused are squeezed outwards, as tongues of molten rock, by the contraction of the still solid portions. In this way the reservoirs of molten rock, necessary to feed the over-lying volcano, are initiated and maintained

objections to this view. Why should some craters be active at a height of 20,000 feet above sea-level, and others at perhaps an equal depth below? Would not the lowest crater tap off the sources of supply of the upper ones unless they were independent? In Hawaii the levels of the molten lavas of Kilauea and Mauna Loa differ by 10,000 feet, and yet the craters are only twenty-five miles apart. Moreover, as we have seen in an earlier article, the idea that the interior of the earth is molten to any appreciable extent must be definitely abandoned.

The Cause of Lavas

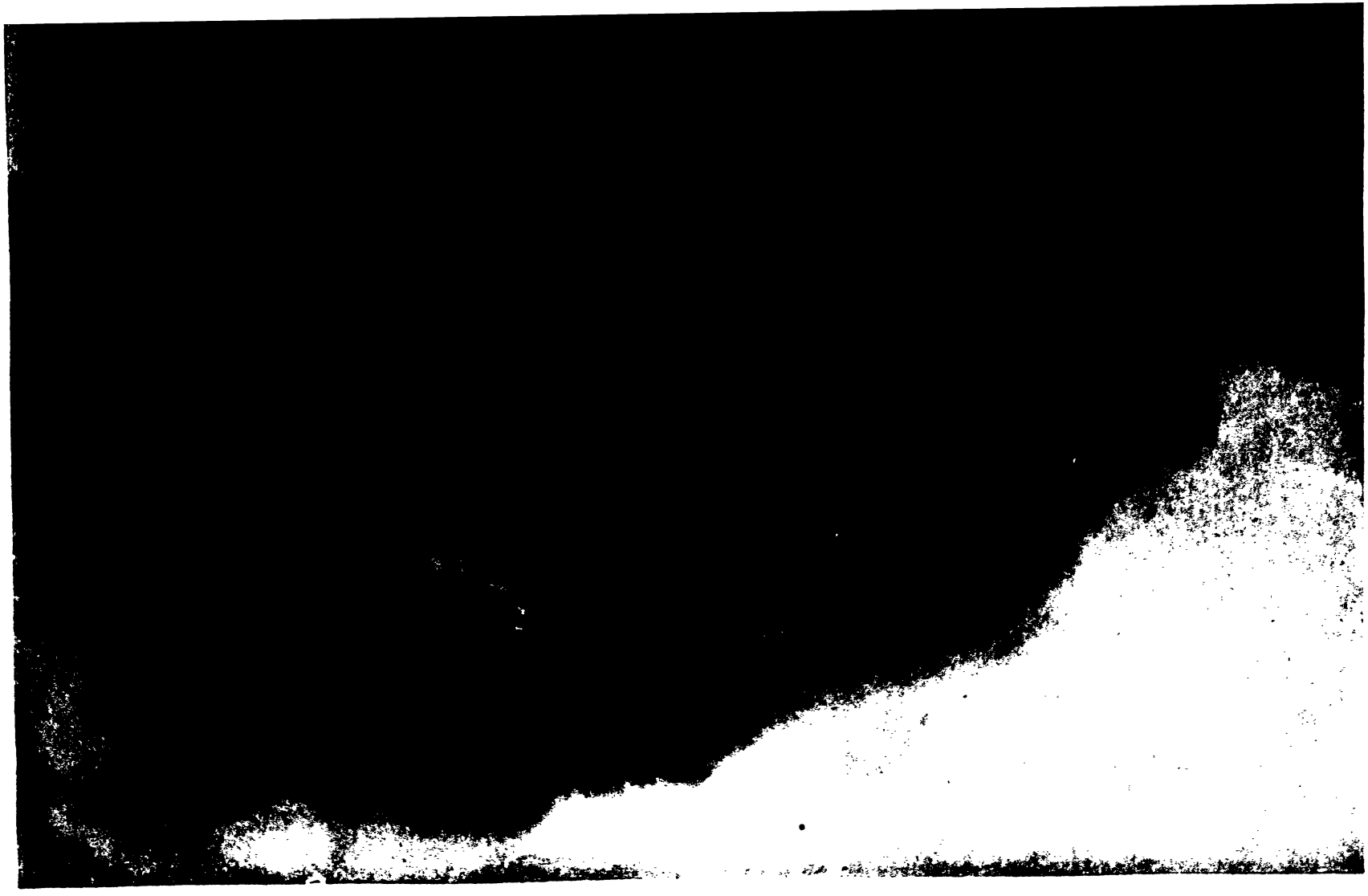
Lavas, then, must be due to the local fusion of deep-seated rocks. If the earth grew up by the aggregation of planetesimal matter, its internal heat would be largely due to its own compression. As the temperature rose, the fusion points of certain of the constituents would be reached before that of others, but actual fusion would only take place comparatively near the surface. Expansion generally accompanies the fusion of solid bodies, and, consequently, deep down in the earth the pressure would succeed in opposing this expansion and preventing liquefaction. The materials most easily fused would be squeezed outwards, as tongues of molten rock, by the contraction of the still solid portions, much as slag is squeezed out of iron fresh from the blast furnace. As the tongues threaded their way slowly upwards, the temperature necessary to keep them in the liquid condition would fall, owing to the reduction of pressure, and a sufficient margin of heat would thus be preserved to carry them into the fractures and fissures of the outer horizons of the earth's crust. In this way the reservoirs of molten rock, necessary to feed the overlying volcanoes, would be initiated and maintained.

The second feature of vulcanism to be explained has reference to the particular distribution of volcanoes, and to the forces which bring about the extrusion of lavas over the surface. The raising of liquid tongues by earth pressure has already been suggested above. Wherever the earth's crust is particularly mobile, one would expect the expulsion of lavas and the production of active volcanoes to be most favoured.

Now this is precisely what is found to be the case. The great majority of existing volcanoes are found around the borders of the sunken area of the Pacific and along the great east and west line which stretches from Central America through the Mediterranean and eastwards to the Polynesian Islands. These belts are again the seat of the greatest earthquake activity. The distribution of volcanoes is, in fact, determined by the junctions of the great uplifted segments of the earth's crust with the great sunken regions. Such junctions are obviously the lines of greatest earth movement, and along them the pressure brought to bear on the slender threads of molten rock is most effective in forcing the lava outwards.

Driving Force of Eruptions

The immediate driving force of volcanic eruptions lies in the gases and vapours with which the molten lavas are charged. Their very presence lowers the specific gravity of the rising columns and thus helps them upward in their onward march. In the depths the gases are imprisoned, and for the time their energies are held in check by the great confining pressures. But when they reach the fissures of the outer crust, a sharp relief of pressure takes place, and they burst out with explosive violence, carrying up with them the lava, and, if their pent-up forces be sufficient, shattering it to dust and ashes of the finest constituency. The part played by steam in volcanic eruptions is a matter of controversy, but the vexed question whether steam is the chief explosive agent or not need not trouble us here.



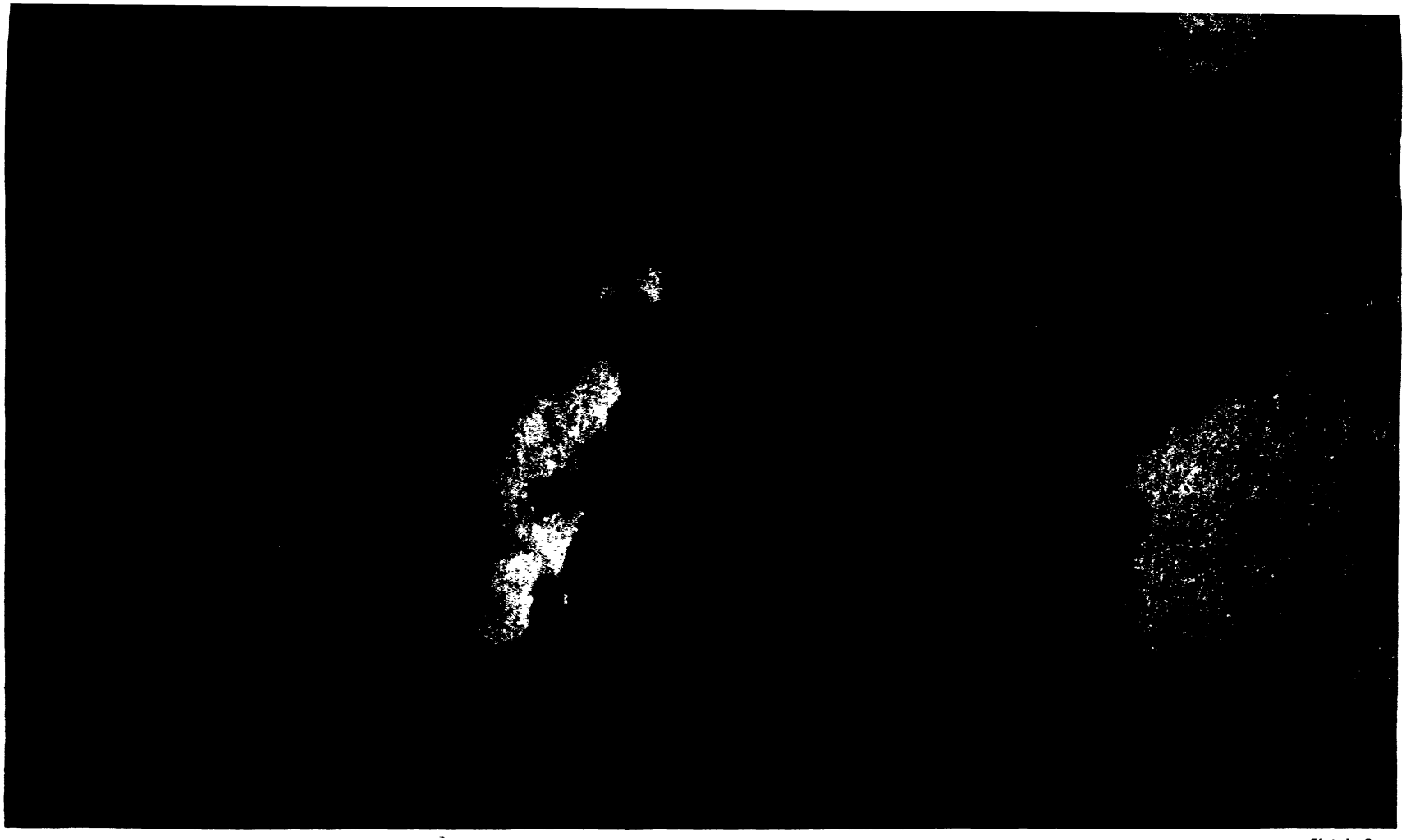


Photo by Perret

Vesuvius in Eruption: A Sunset View

Volcanoes are necessary for the maintenance of stability in our planet; they are indeed a guarantee of security. Our earth insists on breathing out her energy. Volcanoes are safety-valves for the emission of her fiery breath

The other gases which are emitted by volcanoes are themselves amply sufficient to account for the most vigorous eruptions and the most violent dissipation of lava into dust.

The intermittent character of the activity of volcanoes is due to the irregularity of the supply of lava. Deep down in the parent reservoirs the lavas are accumulating, and the forces are gathering their strength.

For a time, however, the earth resists the strain. Then at last all resistance is overcome and a violent eruption is inaugurated. The accumulated energies, perhaps of centuries, are expended in an orgie of destructive fury lasting for a few days or weeks. Volcanoes are necessary for the maintenance of stability in our planet; they are, indeed, a guarantee of security, paradoxical though the statement may seem.

Our earth insists on breathing out her energy. As it is, her fiery breath is limited to a few belts where resistance is least, and safety valves are provided in volcanic vents which are opened out. The only alternative would be a widespread destruction, devastating the whole surface of the earth, and making impossible the onward march of life which is the glory of our planet.

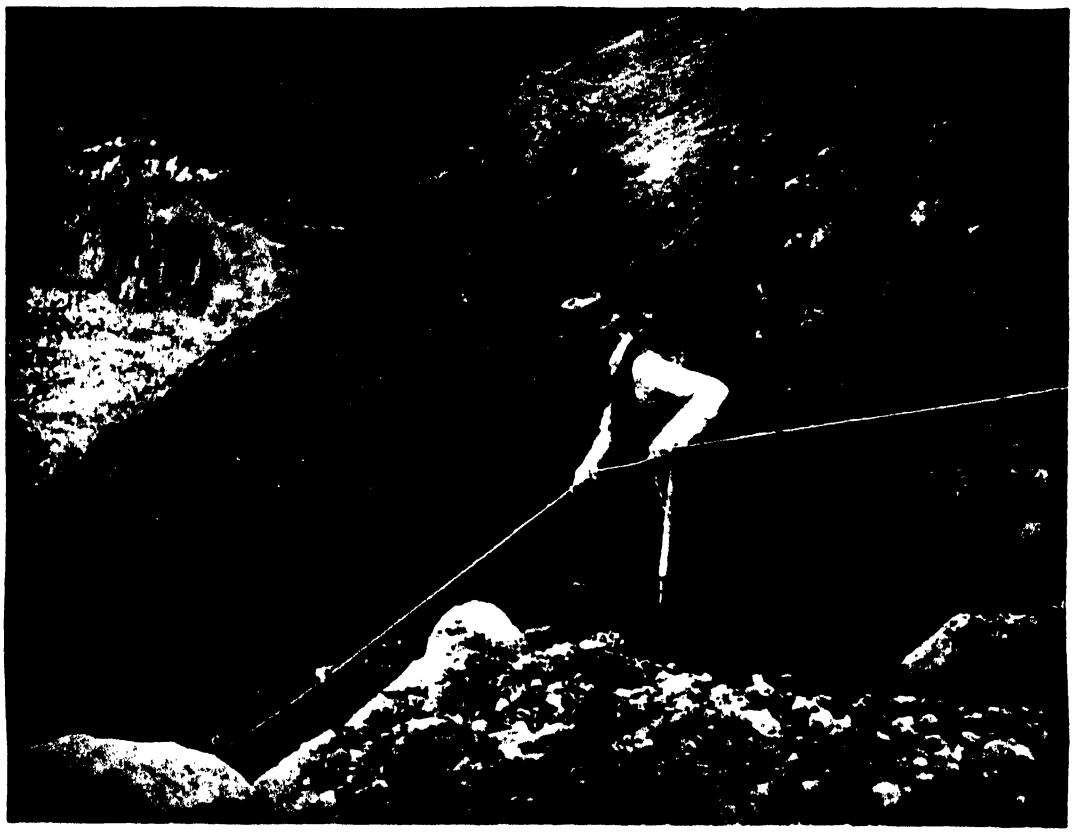


Photo Levy & Sons, Barcelona

Professor Mallenda in the Crater of Vesuvius

During the last few years the importance of the systematic study of vulcanology has been fully realised, and a number of distinguished scholars are co-operating for this purpose. It is hoped that, by this means, eruptions may be accurately prophesied, and loss of life, at least, prevented

Phosphorescence at Sea

Facts Concerning the Light without Heat, furnished by Nature's Laboratory

By HOWARD TRIPP, M.A., Ph.D., F.C.S.

PHOSPHORESCENCE, or the emission of light without appreciable heat, is a phenomenon very widely distributed in Nature. Plants and animals, alive or dead, minerals and microbes, vie with one another in producing this fascinating light, which, although shorn of much of its erstwhile mystery by the illuminating touch of science, is still an object of profound interest to the thoughtful man.

It is sometimes stated that the ancients attributed it to the twin gods, Castor and Pollux, but it is more probable that they associated those divinities with the electric discharge, known as St. Elmo's Fire, which is occasionally seen at sea.

References to phosphorescence at sea are extremely rare in the ancient classics, and it is more than remarkable that a poet like Homer, who sang so much and so often of the "mighty waters rolling evermore," should have omitted to mention one of the most beautiful and enchanting sights in Nature. Darwin describes his observations of it in the South Pacific in the following words: "When sailing in these latitudes on one very dark night, the sea presented a wonderful and most beautiful spectacle. There was a fresh breeze, and every part of the surface which during the day is seen as foam now glowed with a pale light. The vessel drove before her bows two billows of liquid phosphorus, and in her wake she was followed by a milky train. As far as the eye reached, the crest of every wave was bright, and the sky above the horizon, from the reflected glare of these livid flames, was not so utterly obscure as over the rest of the heavens."

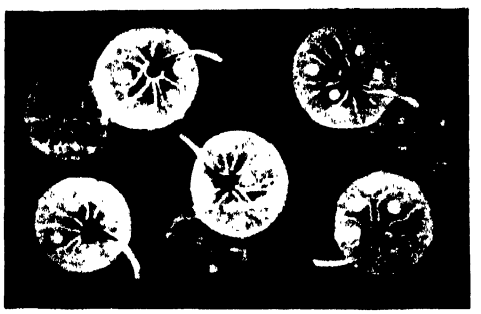
The explanation of this "magnificent spectacle of a starry firmament reflected in the sea" for long remained an unsolved problem, and even to-day there are various points which need further elucidation. In the seventeenth century it was suggested that the waters of the sea gave out at night the light they had absorbed during the day, and the Hon. Robert Boyle put forward the theory that the light of the waves was due to friction generated between the sea and the air by the rotation of the earth.

Luminous Ascidian, Pyrosoma

An observer has written his name with his finger on a giant specimen of this fish, and in a few seconds it has come out in letters of fire

In the twentieth century people still talk of "phosphorus" in the sea. There is no *free* phosphorus in the sea, nor anywhere else in Nature, and the bodies which contain it in a combined form only give it up to the importunities of the chemist with very great reluctance. The true explanation was first given in 1750 by two Italian

professors, who showed that the phosphorescence of the Adriatic was due to very minute, back-boneless sea organisms; and since that time a very large number of these phosphorescent creatures, together with many more highly developed denizens of the deep, have been discovered and investigated. A good example of these lower organisms is the *Noctiluca miliaris*, which is the chief, but not the exclusive, cause of the luminosity of the North Sea and of the English Channel. It is not, however, confined to these localities, but has been observed in climates so widely different as the tropical and the polar seas. Humboldt relates how his body remained luminous for a whole hour after bathing at a spot in the Pacific where *Noctiluca* abounded, and at Ostend they are sometimes present in such tremendous numbers that the damp sand on the seashore appears like molten lava. The appearance of these marine nightlights is very uncertain. They are usually seen in the North Sea on fine calm nights in autumn, but they may be seen at any time. When viewed under the microscope the *Noctiluca* appears like a rounded piece of jelly with a groove or indentation on one side. Across the surface are a number of fine markings which resemble the veins on a leaf, and emerging from the grooved portion is a long "flagellum" or tentacle, which, by means of its energetic lashing movements, sweeps smaller organisms into its mouth, which is situated near the base of the tentacle. The phosphorescent glow emanates from a layer of "protoplasm" or jelly which forms, as it were, the outer coating of the animal. When this tiny creature—and he does not measure more than one-fiftieth of an inch across—attains maturity, it divides itself transversely into halves, and each half grows into a whole and then subdivides again. In this manner the race is propagated at an enormous rate, and, apart from adventitious or violent destruction, it lives on, in its offspring, for ever. The sting of death is unknown to it; it is immortal. These organisms, which are among the lowest forms of life known to man, can be preserved for a considerable time in their native element. If they cease to glow, a drop of alcohol or of weak acid will at once excite them to activity. If a few spoonfuls be filtered off on paper, the light emitted is sufficiently strong to enable one to read at a distance of nine inches. If the water be tested with a delicate thermometer, it can be easily seen that the light is unaccompanied by heat.

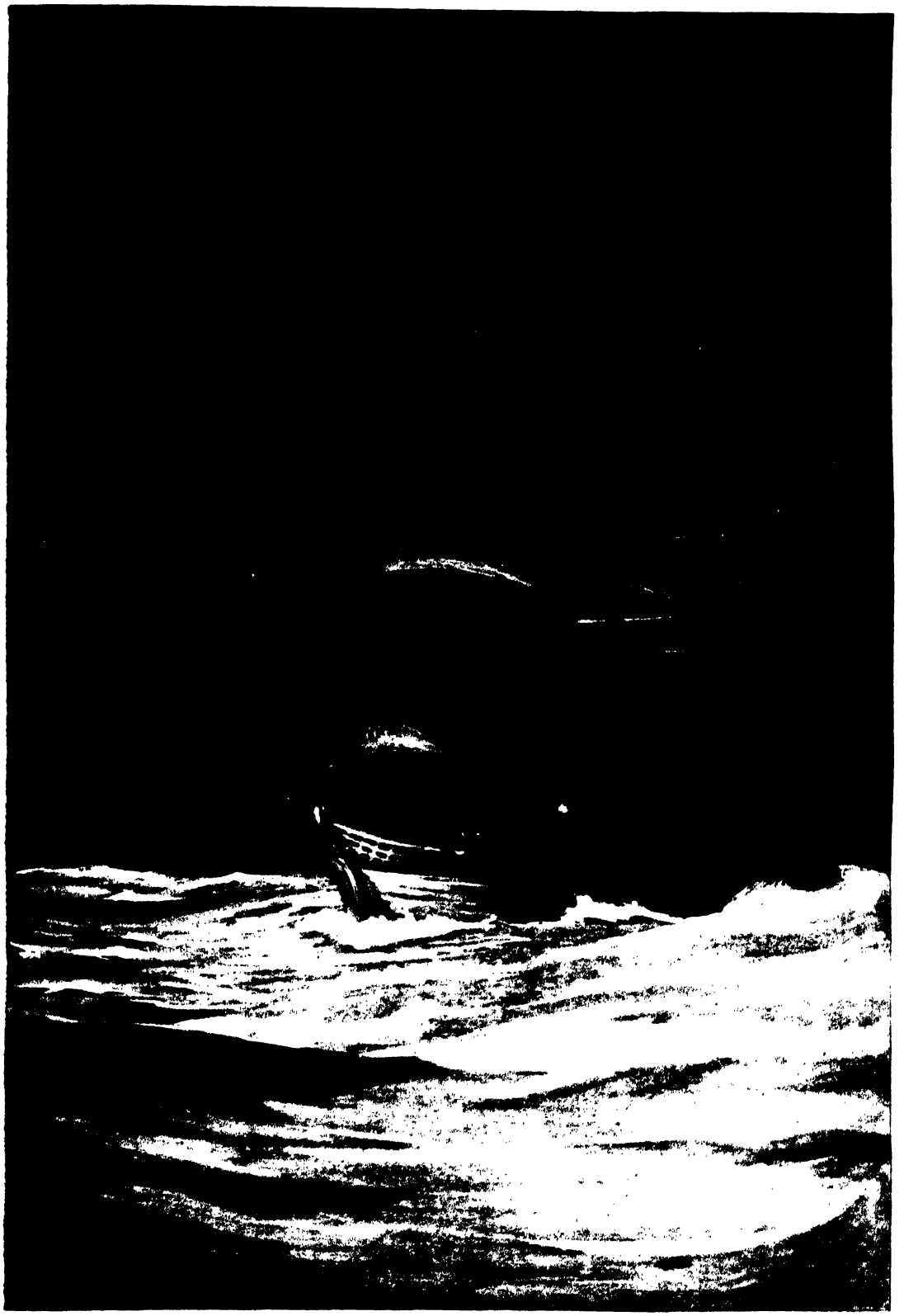


Noctiluca miliaris

The chief, but not the exclusive, cause of the luminosity of the North Sea and English Channel. (Much magnified)

As to the use of this light-giving property nothing is known. In the case of some phosphorescent land insects, such as the glow-worm and the fire-fly, it is under the control of the nervous system, and in all probability serves as a sexual lure; but the *Noctiluca* has no nervous system and no eye, and is entirely without sex.

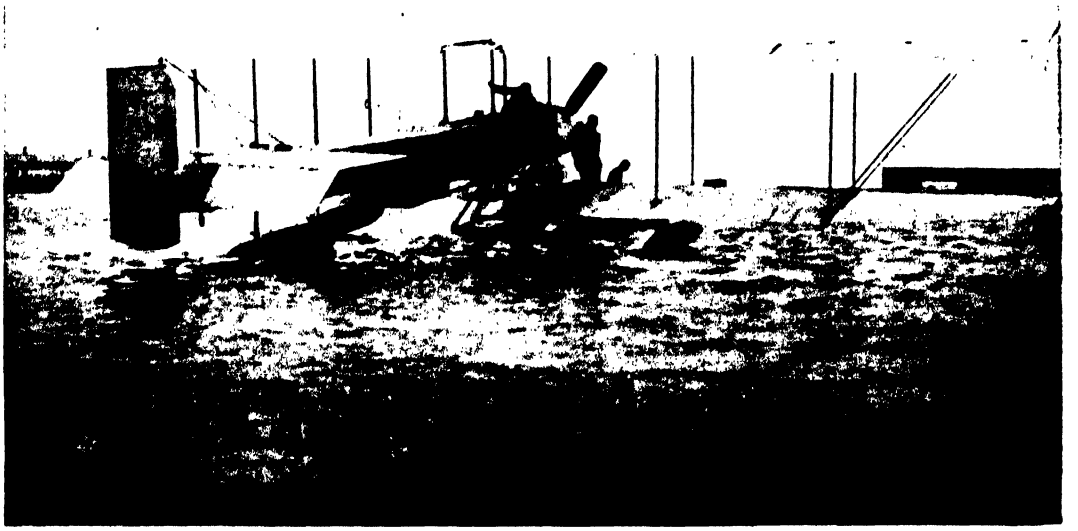
There are so many forms of life which emit this fitful glow in the depths of the ocean, that it is possible that in some way their light serves as a substitute for the rays of the sun, which only penetrate to comparatively shallow depths. But if the scientific imagination has so far failed to find a satisfactory reason for this interesting spectacle, our appreciation of its beauty is thereby in no way lessened; on the contrary, perhaps it is increased.



Phosphorescence of the Sea

Captain Kingman, of the American ship *Shooting Star*, once traversed in the Indian Ocean a zone, twenty-three miles in length, so filled with phosphorescent matter that it looked "like a field of snow"

AIR-BOATS



A British Naval Hydroplane

How the Small Craft of To-day will presently Give Place to Leviathan Multiplane Ocean-crossing Air-liners

HYDRO-AEROPLANES, sea-planes, or air-boats, are machines which will manœuvre in two elements—in the air, and on the surface of the water.

Many such craft at present are merely land-planes with floats, instead of wheels, fitted below their wings. These floats are in the form of pontoons or hollow wooden boxes, and are so buoyant, owing to the air imprisoned within them, that they will support upon the water the total weight of the machine.

When the pilot seeks to leave the water and rise into the air, the engine, actuating the propellor, drives the machine forward across the surface. Then, as it gathers speed, its planes exercise an increasing lift, and tend to raise it bodily into the air. The floats first skim the surface in a boil of foam, then leave it altogether.

The air-boat has an important future, and for several reasons, one of them being that its constructor, not faced by the difficulties of alighting with a heavy machine upon solid ground, may build for use over water a large, powerfully-engined craft. But many improvements are needed, none the less, before the perfected air-boat is produced. Instead of being aeroplanes with floats, and nothing more, such machines need to be specialised craft, and to be increased greatly in size. There are technical questions affecting weight, design, and equipment to be considered; and it is a problem in itself to plan floats which shall be completely efficient. Small air-boats are tossed about by anything like a rough sea, and are unable to withstand the buffeting of big waves. When on water that is genuinely rough, in fact, many

present-type craft are in difficulties; and yet, if this type of machine is to become practical, it must float on the sea when the surface is disturbed, and not be damaged. Large, powerfully-engined machines are needed, constructed so as to ride out rough seas, and withstand the shock of impact with the water. When struck between his office in Chicago and his home at Forest Lake, twenty-five miles away along the shores of Lake Michigan.

An advantage in aerial navigation above the sea lies in the steadiness of the winds encountered. Over the land—broken up by hills, valleys, and woods—the wind is often irregular and treacherous; but above

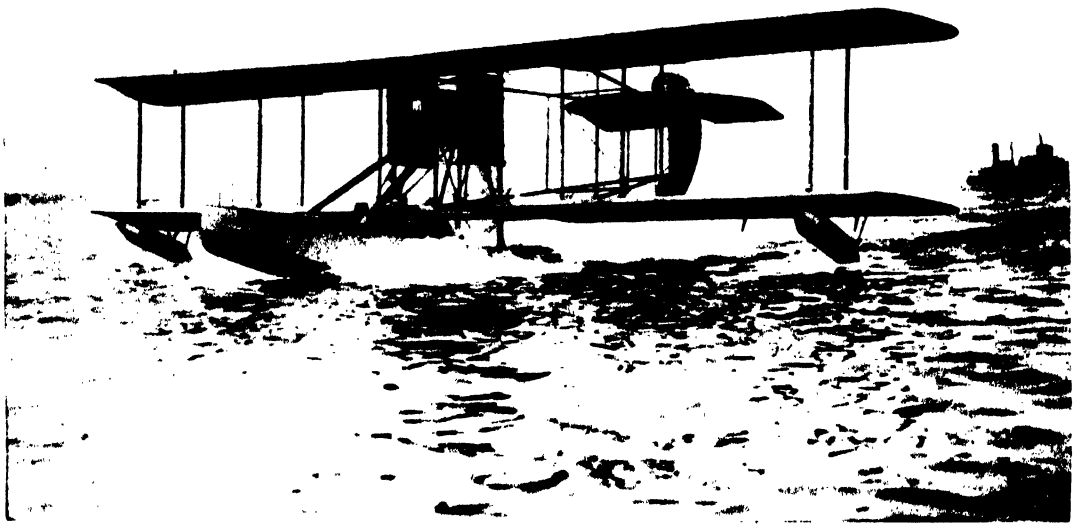


Photo Newspaper Illustrations, Ltd.

Lieutenant Spencer Grey with a Passenger in the "Batboat"

sharply enough—as experimentalists have discovered to their cost—the surface of the sea may appear hard as a concrete bed.

Ambitious machines are being designed and built. One with seats for six people in a boat-like body, and a 200 horse-power engine, has already been tested; another has been built weighing 3½ tons, and having two motors of 200 horse-power each. This will carry twelve people. Nor does such represent a limit; but progress must be slow, seeing that there are many questions to be solved.

Already, however, air-boats are revealing their practicability. Even in 1914 an American was using one daily in journeys the expanse of the ocean it blows with a force which, although strong, is uniform; and it is not the strength, so much as the fluctuations of the wind, that airmen fear.

What is foreshadowed in the future is a type of air-boat grown so greatly in size that it will perhaps merit the description of an "air-liner." Borne aloft by multiple planes, and driven by many motors, such craft will sweep the air at high speed, weathering gales, and linking up nations oversea. Already machines show a tendency to become boats with wings; and this, it is agreed, is in the right direction. Some modern-type craft, for example, have a long, canoe-like body which

rests upon the water and contains crew, motor, and controlling mechanism, while above this body are fixed the air-planes by which the craft ascends.

The pleasures of air-boating are now realised, and daily trips organised between resorts in the south of France. There is nothing more exhilarating than a flight in an air-boat particularly along some pretty sea-coast on a summer's day. The machine makes a smooth, swift rush across the surface of the water; then obedient to the movement of the pilot's controlling lever, it draws itself free without shock or jar, and soars into the air.

There is an aspect of safety in flying over the sea, and it is a point passengers should bear in mind. Many times, during sea-plane tests, machines have made involuntary descents, so abrupt that there would have been serious consequences had they occurred on land; on the water no ill-effects resulted.

Sea-going Craft

Encouraged by recent progress, air-boat builders are now ambitious, and are planning types of craft which shall be sufficiently air-worthy, and seaworthy also, to risk the crossing of oceans. Such machines have not yet been evolved; but there is promise that real sea-going craft will be produced ere long. When motors of high horse-power are available, and the practical necessities more fully realised, striking developments will be seen.

I do not hesitate to predict that, within the next twenty-five years, flying boats will accomplish the journey from London to New York at the rate of 200 miles an hour, and complete their journey in less than twenty hours.

Here, naturally, one joins issue with the sceptic—he who, speaking more often from prejudice than knowledge, would decry the future of flight.

Any craft in the air, for the reason that this element is intangible, and can give no fixed point of support—like the metals of a train—must prove dangerous always: such is his argument. He would illustrate it, no doubt, by referring to the aeroplane accidents chronicled, and the various disasters with airships which have spelt such loss of life. But a law of proportion governs such risks.

Average Safety

After centuries of experience in navigating the sea, we yet mourned the loss of the *Titanic*; but no one would deny the average safety of ocean travel. Sometimes, even now, confidence in our railways is shaken temporarily; yet we know them in our minds to be extraordinarily safe. Before a single catastrophe first challenged their safety, the German air-liners had flown 80,000 miles without the loss of a life, and had carried more than 20,000 passengers in safety; and such immunity from fatal accident had been achieved, one must remember, after a few years' experience only—not after more than a hundred, as with steam.

Aviation mishaps have happened, are happening, and will continue to happen, but each teaches its lesson; and although the sceptic would affirm, perhaps from his lack of precise knowledge, that one aerial journey in six is marred by accident, he might be surprised to learn that, for every flight that ends in disaster, many thousands of miles are now flown in safety.

I contemplated, a little more than five years ago, an aerial trip from London to Paris: but the project was so daring, and obtaining the machine I required so difficult, that I was unable to carry out my wish. Before three years had passed by, however, I found awaiting me in Paris a new monoplane air-boat. Rising in it from the surface of the Seine early one morning, I soon found myself at the French coast. Alighting here for breakfast, I next crossed by air to Dover, lunched on a yacht in the harbour, and in the afternoon flew to London by way of the Thames, landing on the water near Putney Bridge, where friends awaited me,

An Air-Liner of the Future

In a few years time a regular service of multi-planed air-liners will ply across the Atlantic. As a rule they will fly 10,000 feet above the ocean, but in case of emergency they will descend with perfect safety and skim the surface of the sea. They will cover the distance between London and New York in less than twenty hours

and motoring comfortably to my hotel. There was no uncertainty in this flight, nor anxiety as to my machine. It was an easy and pleasant way to make what is notoriously an uncomfortable journey. I had confidence in myself, in the construction of the craft I flew, and in the engine which drew it through the air. I knew that, to the making of each rod and spar, had gone the hard-won experience of builders, and that this experience was my safeguard. Formerly, it is true, machines were frail and broke when in the air; but now, in planning the strength of a craft, makers give it a factor of safety that is many times greater than the strains it may meet in flight.

If, in three years, such progress was made as this, what may not another ten bring? Between the builder today and that perfected air-liner which shall carry its passengers and mails, there is a wide gulf to be crossed; but he sees already some of the bridges by which it may be passed, and he is in no hurry. He knows, as the Wright brothers knew, and all the great pioneers knew, that haste in aviation spells the direst peril. We are combating an element that is relentless as the sea, that strikes when we are least prepared; the only path to victory lies through patient and deliberate labour.

Another Type of Naval Hydroplane

"But," objects the sceptic, "what if your air-liner, when over the Atlantic, and with all its crew and passengers aboard, should collapse in some way, or its planes break adrift?"

This question might be applied to ocean-going liners, which cross thousands of miles of water with such regularity and absence of mishap. They do not break their backs in mid-ocean, because their builders know how, and where, to make them strong; nor will the air-liner of the future collapse, because its builders will know precisely what constructional strength

it requires, and where abnormal strains may be expected to fall. Should its duplicate motors fail, as upon rare occasions do the engines of a steamship, the machine would merely glide to the surface of the water, where it would float in safety until repairs could be made; or, should the mechanical trouble prove serious, until it could come into touch by wireless with shall spurn the wind and fly free and fast, even though gales arise.

It was Cody, whose name will go down through the annals of flight, who said one day: "I am tired of building midgets." If ever man had the prophetic sense, it was he. Cody longed for powerful engines, for heavy, weight-carrying machines; and to that end now does the aerial conquest

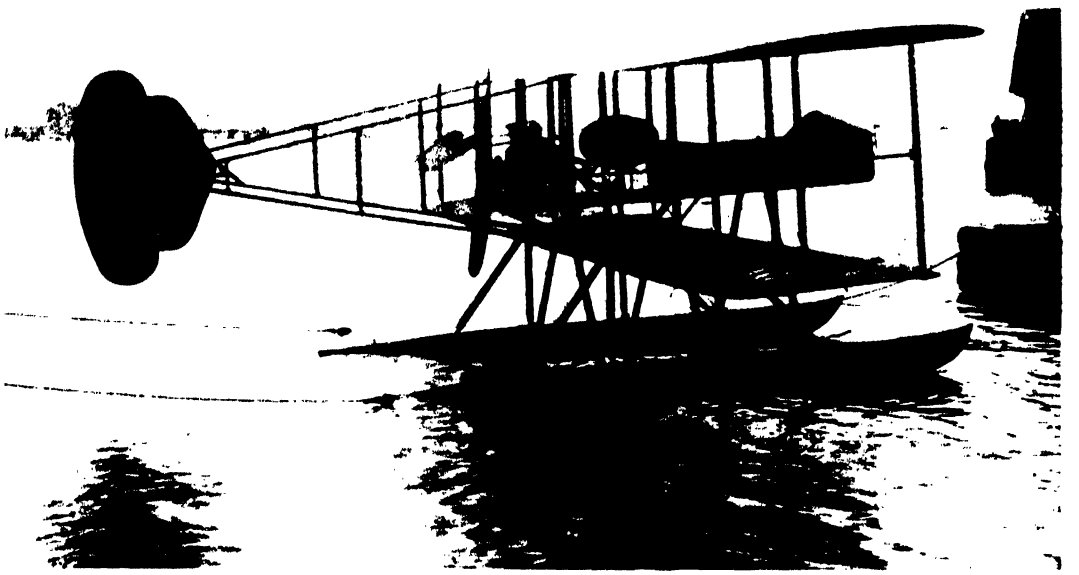


Photo: Newspaper Illustrations, Ltd.

Side View of an Air-Boat

In this type of craft the pilot and his passenger, sitting one behind the other in the canvas-covered, canoe-like body which projects from the front of the machine, have an unobstructed view of all that may be below them

some sister craft. But to argue that aeroplanes are essentially unstable, or that the air must prove dangerous always for the navigation of man, is to cherish delusions which time must prove wrong.

The air-boat of to-day is a cockleshell, tossed by wind and beaten by wave. With it, quite rightly, pilots are chary of a storm.

They know their limitations, and restrain their impatience; but always they have in mind, as have designers and builders too, that powerful, metal-built, many-engined mistress of the air which move. First the oceans will be crossed by swift, pioneer air-boats; then, with their knowledge ripened, and the skill of their workmen increased, will the builders assemble in their shops the first of those multi-planed craft which, flying 10,000 feet above land and sea, will bring a journey of days within the compass of hours.

What this may mean in the growth of understanding between nations, one need not emphasise; the barriers of distance thus broken down, the people of all countries will become next-door neighbours.

Tragedy's Fairest Temple

The Strange Story of the Pearl

By F. A. BRYANT

IT was the story of a wonderful pearl fishery supposed to exist off our coasts that drew Cæsar to Britain. It is the quest of pearls to-day that makes men risk health, life itself, in the terrors of deep waters. What is this lustrous treasure, for which Cæsar plunged Imperial Rome into a protracted and difficult war; this work of Nature which kings still delight to enshrine in their crowns, which lovely women hang in ropes about their necks? It is literally a whited sepulchre, the gleaming tomb of—a loathsome parasite!

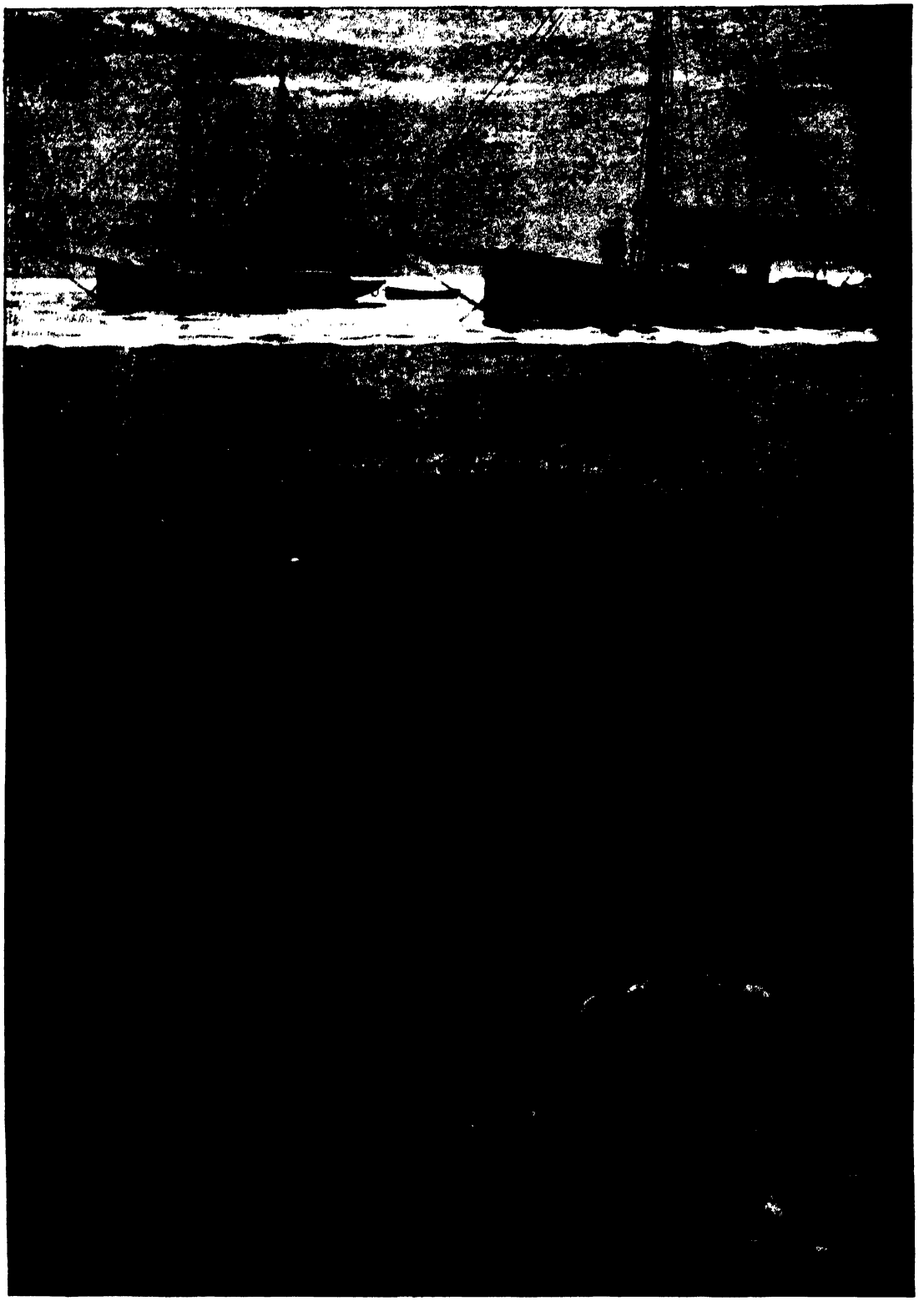
With his electric crucibles of appalling temperatures the scientist can fabricate diamond and ruby in the laboratory—very small and insignificant, but still true jewels, but he cannot make a pearl. All the king's horses and all the king's men cannot match this little thing of beauty. For this we must turn to the meekest of our workmen—the humble oyster or the mussel. The latter, known as river pearls, are of small account; the treasure sought is that which the pearl oyster yields.

It has long been known that the oyster does not create pearls for mere amusement. For many centuries the Chinese have taken advantage of the natural sensitiveness of the mollusc to the presence within its shell of a foreign substance, to get pearls of their own founding by dropping tiny grains of sand or other substance beneath the fleshy mantle of the bivalve. They know that the oyster, unable to rid itself of the irritating intruder, will secrete the precious nacre of which the pearl is formed, bury the grain within it, and so fashion a pearl of more or less value. For ages the heathen Chinee has vexed the fretted oyster into efforts of this kind, and all the world had come to believe that every pearl, big or little, had a grain of sand or other insoluble obstruction for its nucleus. But it proves that a more wonderful story than this underlies the treasure of the diadem and the heirloom.

We know now that only the seed pearls

Photo: Lafayette Studio, Perth, W.A.

A Day's Haul of Pearl Shell in Australian Waters



Scientific Pearling in Western Australian Waters

The dotted lines show the stages, at each of which a diver's ascent to the surface is checked, to enable him to move his limbs vigorously, and thus, by quickening his circulation, drive some of the excess of nitrogen from his body. The reason for this is fully explained in the article "Full Fathom Five" on p. 35

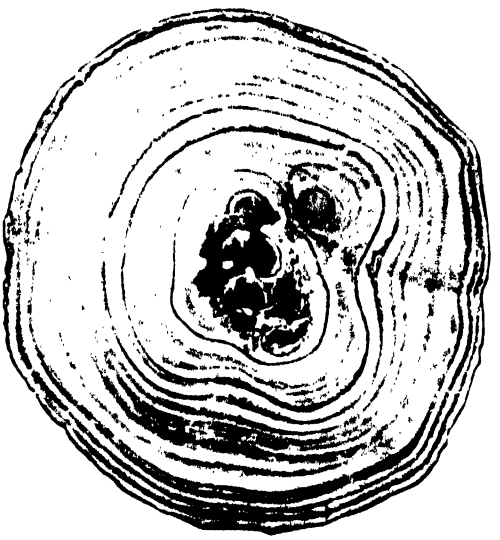
and the blister pearls contain sand. The pearl of price is truly a tomb, the tomb of a hapless victim buried alive within the fortress that it has invaded.

Nearly every creature, small and large, has its special parasite. Fish have theirs. The pearl-yielding mussel itself is at one stage of its career a parasite, existing on the living flesh of the fish to which it attaches itself. Other parasites existing in the deep are of the tapeworm kind, and one of these, a species of Tetrarhynchus, has recently become recognised as of enormous economic importance. Like other internal parasites, this worm cannot complete its life cycle in one host; it undergoes successive stages of its development in successive organisms. The parasite attains maturity within the body of either trigger-fish or shark. The eggs are deposited in the living host, and the larvæ, after hatching, escape in multitudes into the water. Many of them find their way into the depths in which the oysters lie, and enter the bodies of the unresisting bivalves. Some of the tiny embryos reach the internal organs of the oyster, where they are safe for a further stage of their development.

The oyster, irritated by their presence, may succeed in imprisoning them, or may not. But some of the intruders penetrate the mantle of the oyster, and set up an irritation which the host finds insupportable. The oyster cannot eject its growing tormentor, but sets to work slowly to bury it alive. This it does by secreting the calcareous deposit with which it lines its shell. The parasite is held fast by the fluid, which hardens into a substance resembling mother-of-pearl, and entirely envelops it. Layer upon layer of this marvellous secretion is put forth. The oyster must lie snug and smooth; only by covering its enemy with the living coat which forms its sepulchre can the creature gain comfort. Merely to bury it beneath a thin coating does not suffice; stratum after stratum of the nacre is deposited until a pearl incomparable is fashioned with the corpse of an embryonic parasite as nucleus.

An oyster may contain many potential pearls within its body, but only those parasites in actual conjunction with the mantle are sufficiently accessible to enable the host successfully to intern them; those within the muscular body of the bivalve never undergo this form of complete extinction. The story of life has another chapter for these.

Fate and an ill-destined hour bring a trigger-fish to the oyster-bed. The fish



After Ly... James

Section of a Naturally-formed Pearl from the Common Mussel

with its terrific teeth crunches an oyster, shell and all, as nut-crackers split a filbert. The parasites within the fleshy substance of the oyster are swallowed with the rest. They develop afresh up to a certain stage, then tunnel a way through the walls of the trigger-fish's stomach, and become dormant, to await another awakening to which a fresh tragedy must pave the path. A shark or other large fish must now eat the trigger-fish. That done, the gastric juices of the new host re-animate the encysted parasite, which now grows to full size and deposits its ova. These in turn fare forth to infest other oysters, and create new pearls.

At one time the fish that prey upon the oyster-bed were regarded as the bane of the pearl-fisher, but now they are wooed and welcomed like bees to an orchard. The grim and hideous parasite is the beginning of the pearl, hence its warm reception. But could Cleopatra have known what lay at the heart of that £80,000 pearl which she dissolved, that potion would in all likelihood have remained undrunk.

It is safe to assume that the greatest pearls in the world are those which have never been found. The best pearl is never attached to its prison wall, but lies loose in the shell; hence the day must come when the treasure, grown over-large, is washed from the open doors of its living prison, while the lesser ones remain snug within. The pearls dealt with here are, of course, the natural product. The pearl-gemmed figures of Buddha and other deities, which the Chinese and Japanese exhibit, have been placed by human agency within the oyster shell, to be exhibited to the credulous as Nature's tribute to the miraculous nature of Buddhism.

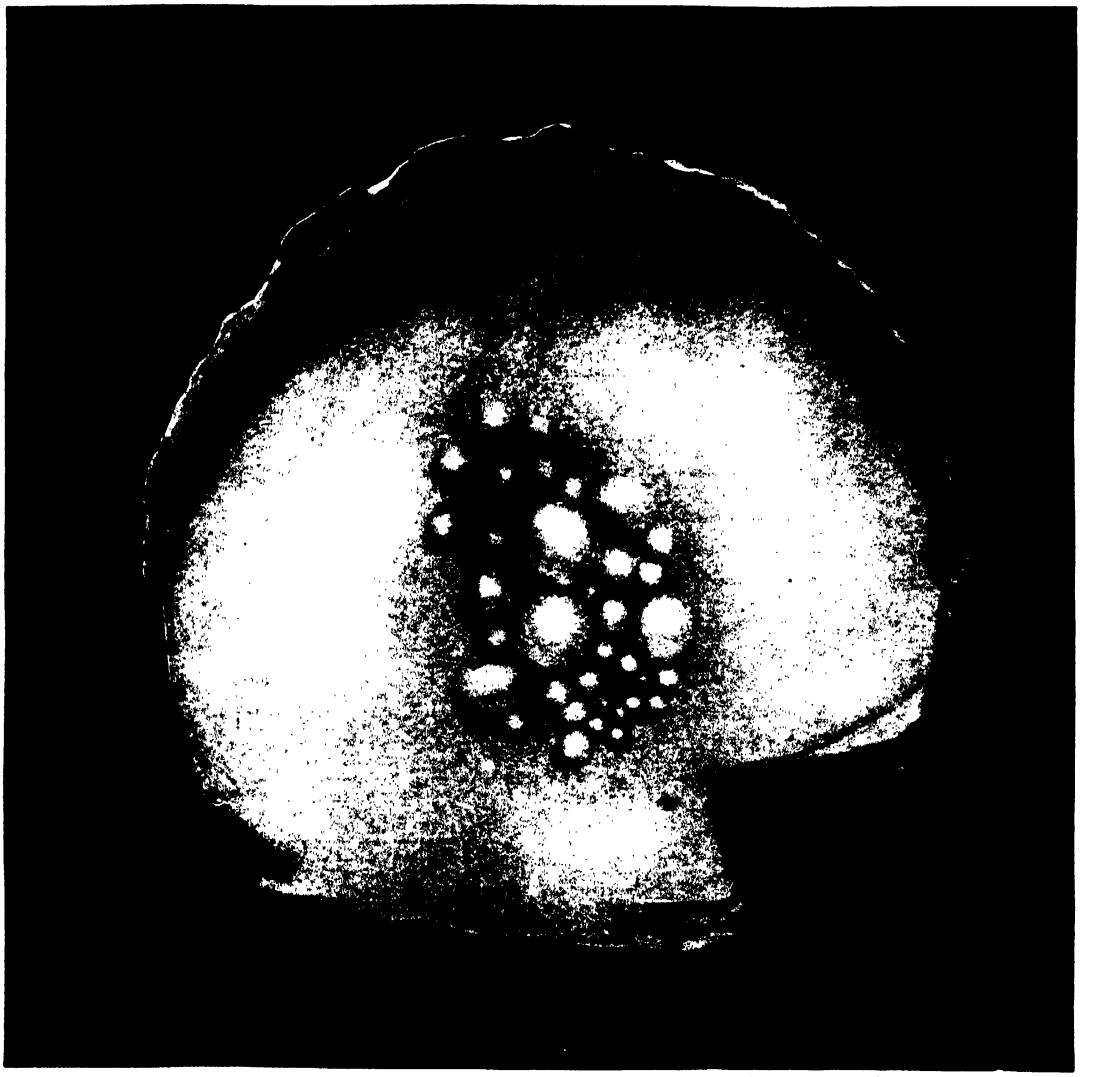


Photo by courtesy of the Queensland Government

Queensland Pearls—exact size

Photo: The Whitman Studios, Malden, Mass.

Miss Helen Keller, one of the World's Most Wonderful Women

A Miracle of Humanity

How one Woman's Courage has Brought Hope to the Blind, Deaf and Dumb of the World

By ERIC WOOD

IF you knew all the joy I feel in being able to speak to you to-day, I think you would have some idea of the value of speech to the deaf. . . . I can remember the time before I learned to speak, and how I used to struggle to express my thoughts by means of the manual alphabet—how my thoughts used to beat against my finger tips, like little birds striving to gain their freedom, until one day Miss Fuller opened the prison door and let them escape. . . ."

The above is an extract from what is surely one of the most remarkable speeches on record, for it was delivered personally by a girl of sixteen who, at the age of nineteen months, had been deprived of sight, hearing and speech. Yet, despite all this and the fact that she was still blind and deaf, she was able to address the Fifth Summer Meeting of the American Association to Promote the Teaching of Speech to the Deaf. How was this great achievement made?

Born in 1880, in Northern Alabama, Miss Keller, by a curious coincidence, numbered amongst her ancestors the first teacher of the deaf in Zurich. When she

was a year and seven months old she was struck down by congestion of the brain, which, passing, left her blind and deaf, and, as a corollary of the latter, dumb. She had been saved from the Valley of Death only to be brought back to a silent and darkness-enveloped world.

There is no need to dilate upon the pathetic little child, who, during the next few years lived without thoughts; whose sole vocabulary consisted of "wah-wah," reminiscent of "water"; and whose communion with friends consisted in feeling their lips as they spoke, in the vain endeavour to understand what was to her "an amusing thing."

A Blind Deaf-Mute

As a child Miss Keller was refractory, and her parents saw that it was necessary to obtain a teacher for her. Through Dr. Graham Bell, of Washington, Mr. Keller secured the services of a graduate of the Perkins Institute for the Blind, Boston—Miss Anne M. Sullivan, who had just recently had her eyesight restored by an operation. Miss Sullivan duly took up her position in the Keller home as teacher to the blind deaf-mute, who was then nearly seven years of age.

The teacher brought with her a doll, which was the subject of the first lesson. Giving it into the hands of the child, Miss Sullivan spelt on to her fingers by means of the manual alphabet "d-o-l-l." Strange to say, Helen imitated this, though she was naturally ignorant of what it meant, having no conception either of words or letters. As a result there was great difficulty in making Helen understand that different things had different names, and that different combinations of finger-movements stood for these. For a long time Miss Sullivan tried to make her realise that "m-u-g" and "m-i-l-k" could not be used interchangeably. The absence of any basis upon which to work made progress seem almost impossible, and, on one occasion, after what had seemed a hopeless task, Miss Sullivan gave it up for a time, and took her pupil for her walk.

That walk led Helen Keller to Paradise.

Miss Sullivan saw someone getting water from a pump, and, as was her habit, sought to make an object lesson of it. She made Helen put her hand under the running water, while on the other she spelt "w-a-t-e-r." Let Miss Keller tell the result in her own glowing words:—

"Suddenly I felt a misty consciousness as of something forgotten—a thrill of returning thought, and somehow the mystery of language was revealed to me. I knew then that 'w-a-t-e-r' meant the wonderful cool something that was flowing over my hand. That living word awakened my soul, gave it light, hope, joy, set it free."

The child now understood that these combinations of finger-movements stood for words which, in their turn, stood for objects or persons, and on that first day a great many words were learned, among them "mother," "father," "sister" and "teacher." "It would have been difficult," says Miss Keller, "to find a happier little child than I was that night as I lay in my crib and thought over the joy the day had brought me, and for the first time I longed for a new day to come. The next morning I awoke with joy in my heart. Everything I touched seemed to quiver with life. It was because I saw everything with the new, strange beautiful sight which had come to me. . . . I was constantly spelling and acting out the words as I spelled them."

Miss Sullivan now took her pupil and gave her to Nature—that great teacher of us all, and for some time the child lived practically in the open, learning to know and to love the beauties of Nature.

The Great Teacher

Helen made rapid progress, and, as soon as she could spell, was given slips of cardboard with raised letters on them out of which she made words which she placed

upon the objects they stood for. Often she would have the various objects placed in position so that a row of them represented a sentence. Then came books in raised letters, through which she hunted for words she already knew, and jumped for joy when she found them.

By this time she had discovered why people moved their lips; they were speaking, and there surged up within the child's breast a mighty impulse to speak.

"I must speak," she had spelt into Miss Sullivan's hand; so teacher and pupil set out for the Horace Mann School for the Deaf, to see Miss Fuller, the Principal. This was on March 26th, 1890. The first lesson began right away. Miss Fuller lightly passed Helen's hand over her face, so that she could feel the position of the lips and tongue when certain sounds were made. The child quickly divined the intention, and as soon as Miss Fuller had finished the movements, her hands flew to her own mouth; she arranged her teeth and tongue in the way that her sensitive fingers had shown her, and uttered her first-acquired element of language. It was only one vowel, but she pronounced it with marvellous accuracy, as she did several others by imitating Miss Fuller.

Photo. Clarke and Hyde

Blind Children Learning Zoology

The photograph shows a class-room at the Institution for the Blind, in Paris

In an hour she had learned m p-a-s-t-i, and could say "mamma" and "papa" with "almost musical sweetness."

Altogether Miss Keller had eleven lessons from Miss Fuller, and, as a result, could speak so that her teachers could easily understand her, although other people might not be able to do so. It was a work requiring infinite patience; new elements had to be learnt, new combinations of elements to make words, new combinations of words to make sentences.

"I am not dumb now!" said Helen to Miss Sullivan after a visit to some friends, during which she had entered into the conversation—after seven lessons!

She now made rapid progress both in reading and speech, gave evidence of literary ability, and before October, 1893, had studied the history of Greece, Rome, and the United States, had acquired a knowledge of French grammar, and also spoke some French. During 1894–95, she studied German, physical geography, and arithmetic, Miss Sullivan sitting at her side and spelling into her fingers the things said by the teachers.

Amazing Determination

October, 1895, saw her at Cambridge School for young ladies, preparing for Radcliffe College, with the determination of taking a degree. The difficulties in the way were tremendous; all the books that she needed were not to be obtained in braille, there was no time to get them embossed, and Miss Sullivan could not spell out all the books into her hands. Therefore Miss Keller had to copy a good deal in braille, so that she could keep pace with the other scholars; she used a typewriter for her compositions and translations. She overcame the difficulties, and in the first year's examinations passed in English history and literature, German, Latin, and arithmetic, taking honours in English and German.

She entered upon her second year with enthusiasm, although once more the lack of embossed books handicapped her, especially as she was taking mathematics, algebra and geometry. She worked her algebraic and geometric problems in class, and also solved her problems in physics, by means of a braille writer. She made her geometry figures on a cushion with straight and curved wires, carrying lettering, figures, hypothesis and conclusion, construction and process of proof, in her mind as she did so.

Then there came a set-back. Mr. Gilman, principal of the school, considered that she was working too hard, and wanted to spread the tuition over five years instead of two; but Miss Keller was anxious to graduate with her class, and the result was that she left Cambridge and studied with a private tutor. In June, 1899, she took her final examinations for Radcliffe, passing in Advanced Greek and Latin, geometry and algebra, finishing in time, despite the fact that she was not thoroughly acquainted with the braille notation used in the geometry and algebra papers, which were copied for her by a gentleman. She entered Radcliffe in 1900, and in 1904 passed her examinations for her B.A. degree.

Such is the story of the development of Miss Helen Keller, who, as all the world knows, has been appointed to teach the deaf-mute son of a European king, who, report says, is making good progress. She has achieved marvels, rising upon the stepping stone of what was almost a dead self to heights of education that normal folk might well envy. She has addressed meetings, delivering speeches of inimitable charm and almost faultless style; has written "The Story of My Life," besides other volumes; and has won a degree by her own magnificent efforts and those of devoted teachers.

Hope for Others

It is all matter for wonder, and it is not surprising that much has been said and written about her—much, as Miss Sullivan, has said, that is not true but greatly exaggerated. The achievement has not been sudden; it has taken time, it has been hard work, yet work that needs no adorning words to reveal its greatness and marvel.

Miss Keller of course is not the only deaf-mute who has been taught to speak, but it is safe to say that no other blind deaf-mute has attained to such heights of culture as she has done.

HARNESSING THE WORLD'S GREAT WATERFALLS

Building the Outer Cofferdam around a Niagara Wheel-pit

Niagara in the Service of Man—How the Electrical Engineer makes the Tumbling Waters work for Him

THE story of the harnessing of the world's great waterfalls to supply power for the benefit of man constitutes one of the wonders of modern engineering science. All over the world to-day the electrical engineer is busy making the tumbling waters work for him. He uses them for driving his trains and trams, for turning lathes and other machinery, and for lighting his streets and houses. Furthermore, this electrical energy, after it has been generated at the cataracts, can be conveyed to cities hundreds of miles distant, and there utilised as required.

Of the large falls, Niagara was the first to be conquered in this unique way. To-day electrical energy equal to 580,000 horse-power is obtained from this single waterfall. This is the combined output of the five power stations that dot the banks of the Niagara River. Two are on American territory and three on Canadian soil. The latter are far and away the largest institutions of their kind in existence, generating 110,000, 125,000, and 180,000 horse-power respectively.

Here it may be mentioned that one horse-power represents the hard labour of at least ten men, so that the Niagara development of to-day seems, at first glance, to represent the energy of 5,800,000 men. But man has elected to work no more than eight hours a day, while Niagara gives out its power from sunrise to sunrise, so that the Niagara development stands for the force of 17,400,000 able-bodied men.

Putting Niagara to work in this fashion has resulted in a great manufacturing city arising on the American side of the falls, in which not a single steam-engine pants, though coal is very cheap in the locality. Even in Buffalo, where coal costs only six shillings a ton, electric power, transmitted 23 miles from the Falls, has completely ousted steam—a fact which is not a matter of astonishment, considering that the generating companies supply current at the rate of £5 per year per horse-power, running

continuously. This works out at less than a farthing an hour. Every year the great electrical tentacles reach out farther and farther, and grip town after town.

Power at One Farthing an Hour

Already the street cars of Syracuse on the east and Toronto on the west—250 miles apart—are operated by Niagara power, as is also a section of the Erie Railway, 150 miles distant. Within a short time from now towns 300 miles away and more will be tapping the energy of the famous falls.

There are two distinct falls at Niagara—the Horseshoe Fall, on the Canadian side of the river, 2,600 feet in width, and with a depth of 132 feet; and the American Fall, 1,000 feet in width, and 162 feet in depth. A solid wall of water, 20 feet thick, representing 275,000 cubic feet per second, passes over the two falls continuously. Its daily force, some 7,000,000 horse-power, equals that of the latent power of 200,000 tons of coal mined every twenty-four hours throughout the world. Although sufficient water has now been withdrawn to obtain an energy equal to 580,000 horse-power, the volume of water passing over the falls has only been reduced in depth by two-and-a-half to three inches, not enough to detract in any way from the scenic effect of Niagara.

There are stories told of tourists visiting the falls who, after being impressed by their grandeur, ask, "Where are the wheels from which the power is obtained?" As a matter of fact, there is nothing at all at the falls themselves to indicate that man has in any way harnessed them for his benefit. But at five points on the river, above the falls, there are little dams or openings into which the water runs, and, by falling upon turbines laid deep down in the bowels of the earth, generates the power. These turbines are in all cases situated from 170 to 180 feet below the surface of the river, and the water is supplied through vertical pipes, known as penstocks.

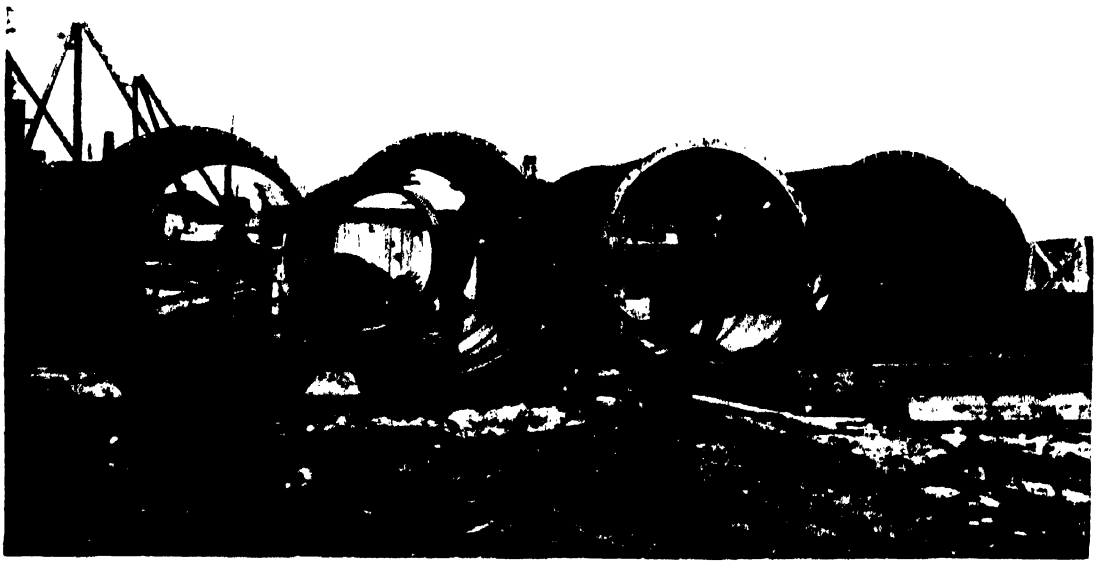
A turbine is composed of a number of vanes set spoke-wise round an axis, and enclosed in a cylinder in such a fashion that all water passing through the cylinder must push the vanes aside in its course, imparting to them, and therefore to their axis, a circular motion. Attached to the turbines are revolving shafts of steel reaching up to the generators in the power-house on the surface of the ground, which operate the dynamos and thus produce the electrical energy.

In the case of the new Canadian power-houses, the tunnels or penstocks are of immense size, and were laboriously cut through the solid rock. The largest is 11 feet in diameter. At their bases there are deep wheel-pits in which the various turbines do their mighty work. To get rid of the water after it has passed through the turbines, channels have been bored through the rock on a gentle gradient to points below the falls.

The tunnel, or "tail-race," of the Niagara Falls Power Company, the first to be erected, is 7,000 feet long, with a maximum section of 21 feet by 18 feet 10 inches. The driving of this tunnel occupied 1,000 men continuously for three years, required the removal of 300,000 tons of rock, and consumed 16,000,000 bricks for its lining. Add the quarrying out of 123,455 cubic yards of rock for the wheel-pits, and it will be realised that here a very considerable engineering feat has been performed.

Driving a Tail-race

Of the Canadian power-stations the largest is that belonging to the Ontario Power Company, the output of which is 180,000 horse-power. Its erection was a bold and daring undertaking. About a mile above the falls a great wall 600 feet long was built out obliquely into the river, slanting downstream. From here water passes into the tunnel and down on to the turbines in the giant wheel-pit, an ingenious arrangement of sluice-gates and gratings keeping back any ice that is brought down



1. Power-house of the Niagara Falls Power Company
2. Sections of one of the big Penstocks at Niagara
3. Draft Tubes en route to the Canadian Niagara Power Company

by the river during the winter months. The tunnel or penstock is 7 feet by 15 feet, and from its base a lateral tunnel, 8 feet by 15 feet, has been driven out, 400 feet back of the Horseshoe Fall, to carry off the "dead" water.

The piercing of the rocky cliff in the rear of the Horseshoe Fall by this lateral tunnel was one of the most notable engineering exploits Niagara has known in connection with its magnificent power development. As the wall of rock grew thinner and thinner, as the tremendous blasts tore a hole for the first time through the awful mass of rock, the men engaged on the work watched for the glimmer of light that would indicate a breaking through behind the waterfall. Finally, an opening was made, but the water poured through it in such tremendous volume that the tunnel was flooded.

It was found necessary to lower a boat down the shaft. Three men entered it, carrying four boxes of dynamite, their intention being to place it so that its discharge would tear a full opening in the rock at the tunnel portal. Along through the dark channel of the lateral tunnel these three men, lying on their backs in the craft, and working their way along with hands and feet placed on the roof of the rock above them, made their way to the hole that opened into the gorge behind the great waterfall. One by one they crawled through the opening, and then they placed the dynamite where the explosion would be likely to do the most good and rend the solid rock in accordance with the desires of the contractor.

Niagara Falls

By taming only a fraction of this mighty water power, engineers have harnessed almost incalculable energy for their own use

Then they returned to the shaft, and an electric current was sent along the wire they had laid. The blast was exploded, but later investigation revealed the necessity for more dynamite, and men made their way along a ledge behind the sheet of water, placing dynamite at a desirable point. This blast had the desired result, and after it had been shot the tunnel was left comparatively dry, the inflowing water easily finding its way to the lower river.

This tunnel, of course, was constructed with no other intention than to get rid of water which had served its purpose after passing through the turbines. It has, however, become one of the "side

Photo: Underwood & Underwood

From Waste Water to Man's Servant—Electricity

A remarkable photograph of the interior of a Niagara Falls power-house. The dynamos shown here are of 5,000 horse-power. There are 25 revolutions per second, producing a current of 2,200 volts

shows" of Niagara. Hanging from the roof of this tunnel is a "visitors' gallery," along which, 158 feet beneath the river bed, yet all the while overlooking a torrent of mighty waters, the traveller may make his way to the very interior of the falls. In front of the tunnel's mouth, but 60 feet distant from the face of the rock, falls a curtain of water, the intervening space being filled with clouds of blinding spray, hurled about with terrifying fury.

A Curtain of Water

So far as the power-houses are concerned, all that the visitor detects are rows of mighty dynamos, the largest in the world, while he is conscious of a ceaseless hum. This is caused by the armatures as they spin round at a speed of 1,500 revolutions per minute. The outcome of this activity is that power is generated, and, by means of specially designed cables, carried to distant places to be used as desired.

In the same way man will harness the famous Victoria Falls, on the Zambezi, in South Africa. These falls have a drop of close upon 400 feet and are more than a mile in width. Their potential energy is estimated to be fully 35,000,000 horse-power, several times as great as that of Niagara. Here it is interesting to note that if the whole of the waterfalls of Europe, both large and small, were utilised in the service of man to-morrow, they would not aggregate more horse-power than that which could be obtained from this single waterfall in South Africa. So far man plans only to tap a fraction of this enormous energy now running to waste at the "Roaring of the Waters," namely, some 150,000 horse-power, less than one two-hundredth part of the whole. The station that will be erected on the banks of the Zambezi will rank as the largest and best equipped of its kind in the British Empire. More wonderful still, it will convey electricity to the gold mines on the Rand, some 600 miles away. As Rhodesia develops towns will no doubt spring up, in the neighbourhood of the falls, whose factories will be driven by power obtained from this mighty cataract. Engineers tell us that they could obtain energy representing 5,000,000 horse-power from these falls without robbing them of their majestic beauty.

As Niagara and other noted falls have been harnessed so, no doubt, in course of time, the same fate will overtake the Yguazu Falls situated on the river of that name, a tributary of the Parana, in South America. These falls are over two miles wide and have a drop of 215 feet. Here is continually running to waste some 14,000,000 horse-power. This is approximately equal to the aggregate water-power of all Scandinavia, which is so rich in waterfalls, or ten times the total water-power of Germany.

The great waterfalls of Europe have long been harnessed to the service of man. The Rhine Falls at Schaffhausen, the most voluminous of European waterfalls, now generate electricity for a variety of purposes. Then the Rjukan Falls of the Maan-Elf River, in the Norwegian province of Telemarken, have been tamed recently, a 125,000 horse-power plant having been erected there. This is the highest waterfall in Europe. The principal fall is 800 feet high, and the total height of the two chief falls with the intervening rapids amounts to 1,837 feet, while the average flow of water is 1,760 cubic feet per second. The Falls of Trollhattan, the most celebrated of all Scandinavian waterfalls, now work for man, generating something like 40,000 horse-power. Indeed, the total energy man obtains to-day from falling water, in Europe alone, represents, it is estimated, not less than 8,650,000 horse-power. Yet we are but on the verge of a revolution in our methods of obtaining energy for locomotion, lighting, heating, and factory operations, for there are many falls and large volumes of water still running free that are capable of being tamed for man's service.

Other Mighty Falls

SAHARA DESERT—1

[illegible] G.C.M.G., K.C.B.

The Home of the Simum - A "Dreadful Wilderness," nearly the Size of Europe—How it is Slowly but Surely Extending in Area

THE Sahara Desert is calculated as occupying the enormous approximate area of 3,500,000 square miles, if one includes within its limits all the arid regions of North and North-Central Africa, without flowing rivers or fresh-water lakes, between the valley of the Nile on the east and the Atlantic coast on the west. Therefore, the Sahara Desert (which might be further divided into the Sahara proper and the Libyan Desert, the two being separated by the long north-west to south-east Tibesti tableland) is equal in area to the whole of Europe, minus the extreme Arctic regions of Russia.

This region, by its recent conditions of aridity, has played a very notable part in shaping the history of Africa. It has been the means of cutting off easy access between Mediterranean Africa—Mauretania and the Tripolitaine—and the fertile regions of the Sudan and Central Africa. Down to some thirty years or so ago it was popularly believed not only that the Sahara was a region mainly covered with shifting sands, but that these sandy wastes represented an area once covered by the sea; that they were, in fact, the upraised bottom of an ancient sea, that stretched right across from the eastern half of the Mediterranean to the Atlantic. Some writers even exaggerated the fact of the existence of a small area in Southern Tunis, below sea-level, into the theory that much of the Sahara surface was below sea-level at the present day, and that, if a short canal was cut in the vicinity of Gabes, in Southern Tunis, and the waters of the Mediterranean introduced into the *shats*, or salt lakes, which, in a nearly dried-up condition, still exist in

that region, a considerable proportion of the Sahara might be flooded with sea water.

A more careful examination by French, German, and British geographers and geologists has enabled us within the last few years to arrive at a much more correct understanding of this desert region. Firstly, there are only a few areas of very small extent below the level of the ocean; one

A Typical Oasis in the Desert

of these lies in the south of the Regency of Tunis, and the others are dotted about the south-western Sahara, between the sand-dunes of Igidi and the valley of the Niger. Both series of depressions—that is to say, the country of the *shats* in Southern Tunis and South-eastern Algeria on the north, and the Juf and Hodh hollows to the north and west of Timbuktu—represent regions which, in comparatively recent times, were the bottoms of shallow lakes (probably salt), vestiges of former incursions of the sea. Earlier still in pre-history there was not only a considerable gulf of the Mediterranean stretching across Southern Tunis to the confines of Algeria, but the sea covered nearly all Senegal, and penetrated south of the Adrar tableland into what is now the north-eastern basin of the Niger. There were probably in those days two "Nigers." The main stream of one flowed from the southern flanks of the Atlas Mountains along the route which will some day be traversed by the great Trans-Saharan Railway, and which is noteworthy for its string of oases—Figig, Gurara, and Twat—nearly due south to the region of Timbuktu. Here it met the abundant waters flowing down from the mountains of Senegambia, and joining with them formed a great basin of fresh water, which communicated with the Atlantic ocean through Adrar. The other Niger rose in the lofty mountain region of Ahaggar, in the very middle of the Sahara Desert, and perhaps received contributions of water from the region of Lake Chad across Bornu and Sokoto. At first, this second Niger contributed to form a vast lake in the very heart of Africa, which communicated with the basin of the western Niger and with the Atlantic Ocean. Indeed in Cretaceous times, before the great age of mammals, there must have been continuous water communication between the Chad basin and the Atlantic Ocean through Senegal, and, though actual incursions of the sea probably stopped in the Eocene period, the general outlet of the Chad basin must have been westwards towards the Atlantic along the valley of the upper Niger, before the eastern half of the Niger system had pierced through the mountains of the south and found its way to the Gulf of Guinea. This theory is not only attested by the discovery of many marine and fresh-water fossils, but by the existence at the present day of that aquatic Sirenian mammal, the Manati, which was evolved

A Dreadful Wilderness of Sand

This photograph illustrates a typical scene in the vast desert where the frontiers of Morocco meet those of Algeria. Contrary to the popular impression, the desert is not usually a more or less flat waste, but is broken in all directions by ribs of rock, stony tablelands, lofty table mountains, and grim, [illegible] under which whole armies might well have been buried

Sahara Desert—I

anciently along the southern shores of the Mediterranean (as we know from the fossils of Egypt), whence it reached the Atlantic coast and the West Indies. Now the Manati—utterly incapable of moving a yard overland—is still found at the present day in some of the lakelets near Lake Chad and all along the upper Niger.

But a very large proportion of the Sahara Desert rises high above sea-level,

Photo, Sir H. H. Johnston

A Pool of Water in an Ancient Dried-up River

reaching in some of the mountains of Tibesti to nearly 9,000 feet, and on the Ahaggar plateau, where snow lies for two or three months of the winter, to elevations between 7,000 and 8,000 feet. The greater proportion of the desert surface consists of bare rock, or of tracts of loose stones and pebbles, most of these having a water-worn appearance as though they had been rolled about by mountain torrents. A comparatively small portion of the area of the true Sahara Desert (west of 20° E. longitude) consists actually of loose sand or sand-hills; and although, under the action of the wind, sand-hills are still, on a very small scale, created and dissolved, and thrown into huge ripples like the waves of the sea, the greater part of the dunes (rising sometimes to a height of 300 feet above the surface) are now more or less fixed in outline, and are evidently gradually settling down into a new sandstone formation.

Although sand-storms are frequent at certain times of the year in the true Sahara, it is doubtful whether incidents have really occurred within historical times of caravans being overwhelmed and actually buried under the driven sands. These incidents are chiefly attributable to the Libyan Desert, eastwards of the great Sahara backbone of Ahaggar-Tibesti. The Libyan Desert, which stretches nearly due north to south, from the limestone hill ranges of Barka to the confines of Darfur and Nubia, is a region of shifting sands nearly 500,000 square miles in extent. This has justly been called "a dreadful wilderness." There is no middle route across it, at any rate at the present day, though in its western portion there are the habitable oases of Kufra and Kebabo, and in the south-east the oasis of Zaghawa. Here, indeed, is a waste of sands rising in low ridges to scarcely more than sixty feet, wherein the north-west and south-east winds raise enormous volumes of sand high into the atmosphere, sufficient to bury whole armies like that of Cambyses, which is supposed to have perished in this region in attempting to reach the Sudan. From the sands of the Libyan Desert come the worst of the "scirocco" winds which blow across Italy and Greece charged with the fine particles of red sand. "Scirocco" is a mediæval Italian word derived from the Arabic *sharaq*, "south east," said to be the origin of the word "Saracen."

One of the best accounts of the true

The Scourge of the Desert

"The simum felt like the blast of a furnace" wrote [illegible] when [illegible] had encountered its fury. "Filled with the whirlwind, and charged with thunder, it urged its fiery course [illegible] with its death-laden breath. It was accompanied by a line of livid light, that looked like a train of fire [illegible] and made the hottest only [illegible]

desert whirlwind, or simum, is that of James Bruce, the Scottish explorer of the second half of the eighteenth century, who explored Tunis and Tripoli and rediscovered the sources of the Blue Nile.

"On November 14th, at seven in the morning, we left Assa Nagga, our course being due north; at 1 o'clock we alighted among acacia trees at Wadi el Halbub, having gone twenty-one miles. We were here at once surprised and terrified by truly one of the most magnificent sights in the world. In that vast expanse of desert, from west o north-west of us, we saw a large number of pillars of sand at different distances, at times moving with great celerity, at others stalking on with a majestic slowness; at intervals we thought they were coming in a very few minutes to overwhelm us, and small quantities of sand did actually more than reach us. Again they would retreat, so as to be almost out of sight, their tops reaching to the very clouds. Then the tops often separated from the bodies, and these, once disjointed, dispersed in the air, and did not appear more. Sometimes they were broken near the middle, as if struck with a large cannon shot. About noon they began to advance with considerable swiftness upon us, the wind being very strong at north. Eleven of them ranged alongside of us, about the distance of three miles. The greatest diameter of the largest appeared to me, at that distance, as if it would measure 10 feet. They retired from us with a wind at south-east, leaving an impression upon my mind to which I can give no name, though surely one ingredient in it was

Photo Sir H. H. Johnston

The Outskirts of a Saharan City

Photo: D. McLeish

The East Gate of Biskra

This beautiful oasis in the Sahara is planted with 200,000 date palms. The gates (the "strait gates" of the Bible) are closed at night to keep out wandering desert tribes

fear, and a considerable deal of wonder and astonishment. It was in vain to think of flying; the swiftest horse or fastest sailing ship would have been of no use to have carried us out of danger.

"November 15th. At 7 a.m. we left Wadi Dimokes. The same appearance of moving pillars of sand presented themselves to us this day, in form and disposition like those we had seen at Wadi el Halbub, only they seemed to be more in number and less in size."

The Scourge of the Desert

As the colour plate shows, the simum, as described by eighteenth and nineteenth century writers, must have presented a majestic and awe-inspiring spectacle. Its advent was usually signalled by the appearance of a rapidly-spreading haze extending from the horizon till the whole sky was obscured by it. Then a hurricane, blowing from the south or east, drove columns of heated sand before it. There was no escape from its red scourge. Even at a distance from the actual storm "the eyes become red, swelled, and inflamed, the lips and skin burnt and chapped, while severe pain in the chest is generally felt in consequence of the quantities of sand unavoidably inhaled."

"The simum felt like the blast of a furnace," wrote Davidson, the English traveller, of the early nineteenth century, who once experienced its fury. "To describe this awful scourge of the desert defies all the powers of language. The pencil, assisted by the pen, migh perhaps afford a faint idea of it; winged with the whirlwind, and charioted with thunder, it urged its fiery course, blasting all Nature with its death-fraught breath. It was accompanied by a line of vivid light, that looked like a train of fire, whose murky smoke filled the whole wide expanse and made its horrors only the more vivid. The eye of man and the voice of beast were both raised to heaven, and both then fell upon the earth. Against this sand tempest all the fortitude of man fails, and all his efforts are vain. To Providence alone must we look. It passed us, burying one of my camels. As soon as we rose from the earth, with uplifted hands for our preservation, we awoke to fresh horrors. Its parching tongue had lapped the water from our water-skins, and, having escaped the fiery hour, we had to fear the still more awful death of thirst."

Since the occupation of Egypt, and still more the reconquest of the Sudan, British and German travellers have frequently penetrated the Libyan Desert. We do not hear such sensational accounts of simum storms, yet they have frequently been photographed and appear very terrifying as a spectacle. If there is not such imminent danger of travellers being completely choked and covered with the sand in the main Sahara, the air of this region is at times charged with fine particles of grit, most irritating to the air passages, the eyes, and the skin. It is for this reason that the Tuareg and the Tibbu peoples of the desert wear the lisham, or face-veil, which screens their nose and mouth from the wind-driven sand.

A Shifting Landscape

Even the present writer, riding in sandy regions of the northern Sahara, has felt a slight sense of dismay in seeing the freshening wind shifting the landscape under his horse's feet, the whitish sand fleeing before him almost like a mist, shutting out the horizon, building up dunes against some barrier of scrubby vegetation, or the dune dissolving as he rode up it, and the horse seeming to plunge into impalpable ground.

This sand, of course, is not the sand of the sea, but the grit of the dissolving rocks, chiefly those of recent age. The temperature of the rocks during the daytime is heated to something like 200° Fahrenheit, and in the intense cold of the night (owing to the rapid radiation and the absence of

moisture in the air) drops to below freezing point. The alternate expansion and contraction leads to the rapid crumbling of the rock surface, and the terrible winds do the rest in resolving these friable rocks into sand and using the sand as an instrument with which to scrape and scour and dissolve other rock surfaces.

Steadily Decreasing Rainfall

It is obvious from a number of indications that, although the condition of the Sahara has for the past 100,000 years or so been one of steadily-decreasing rainfall, it has not always exhibited its present dreary aspect.

A good deal of the desert's surface, even within the human period (which may be roughly estimated at the last million years of the earth's history), has lain under shallow water, salt or fresh, and possibly these great lakes degenerated into impassable swamps before they became completely desiccated and covered with sand. But in (what we call) ancient times, it is more likely that the Sahara and Libyan Deserts, as regions separating North Africa from Tropical Africa, were obstructive less by their aridity than by their untraversable lakes and swamps. Yet there existed in all times the great mountain bridge of Ahaggar-Tibesti which connected Algeria, Tunis, and Morocco with Bornu, Wadai, and Darfur, rising high above lakes and swamps, and (in later days) impassable sands. Across this backbone of the Sahara must have passed from north to south many species of mammals and many human races.

Although a good deal of this region is volcanic and has been covered in recent times by outpourings of lava, while other tracts are naked stone on which nothing could grow, its innumerable valleys and recesses held fertile soil and nourished an abundant vegetation, made possible by an ample rainfall. This rainfall right across the middle of the Sahara sent great rivers flowing to the systems of the Niger and the Nile, to the Atlantic and the trough-like depression south of Algeria-Tunis. The snow-clad Atlas Mountains sent their tribute southwards towards the Sahara; indeed, it may be said almost without exaggeration that the most northern feeders of the western Niger system still rise on the southern flanks of the Atlas in the vicinity of Figig.

In ancient times there were vast forests of trees partaking equally in character of the once magnificent vegetation of Southern Europe (similar to that now existing in southern North America and in the Canary Islands) and of the flora of Tropical Africa. Vast herds of elephants and giraffes, antelopes of all kinds, rhinoceroses, and perhaps wild asses, wandered to and fro over this now desolate region which, however, still contains some antelopes, a few wild asses (it is said), and even a few giraffes. Hippopotami were found in every watercourse, their semi-fossilised bones now testifying to their former abundance. So also were crocodiles. Lions, leopards and hyenas preyed on the antelopes and buffalo, amongst the buffalo being that amazing species—*Bos antiquus*—with horns fourteen feet long.

Worsening Conditions

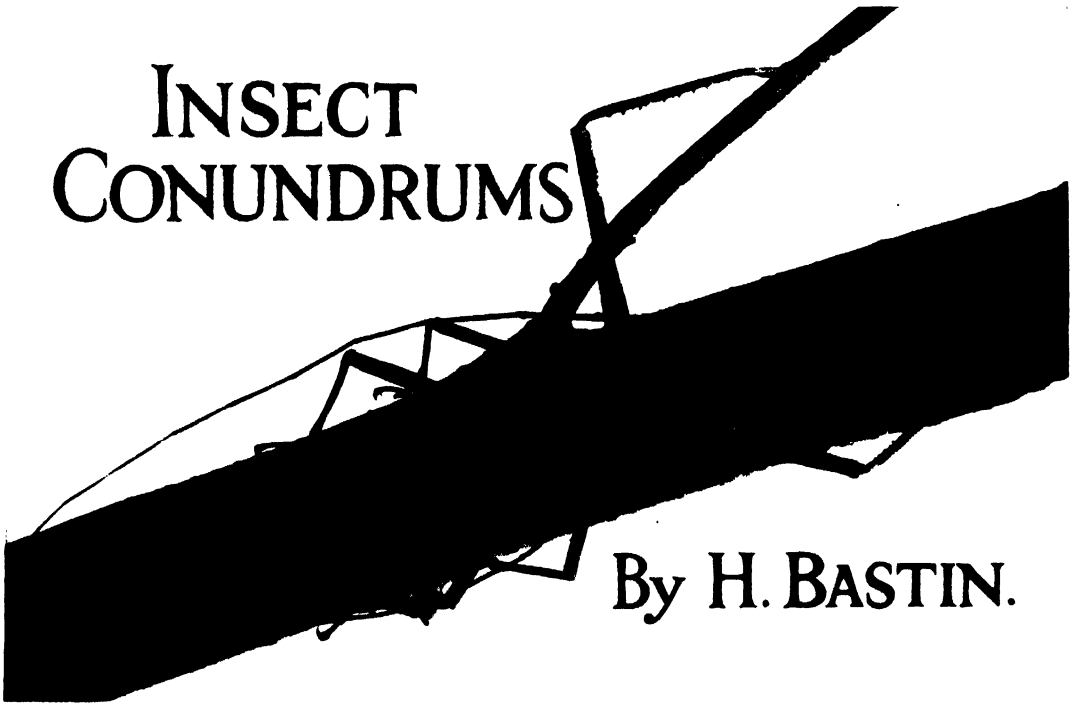
What precisely caused this loss of rainfall in Northern Africa we do not yet know; it may have been due to a rise in level, and the drying-up of the great lakes of the Sahara. But there is a good deal of evidence to show that the worsening of the conditions has proceeded at a very rapid rate during the last 2,000 years, and that a good deal more of the Sahara was habitable and traversable 3,000 years ago than is so now.

Photo: J. Geiser, Algiers

The Ship of the Desert in Northern Africa

In this desolate region, where few animals save the camel are now to be met with, there was once an abundant fauna. Through the well-watered land vast herds of elephants and giraffes wandered; there were antelopes, rhinoceroses, and, perhaps, wild asses; hippopotami were found in every watercourse, so also were crocodiles

INSECT CONUNDRUMS



By H. BASTIN.

The Harlequin Beetle from Tropical America

Some of Nature's Riddles—Useless Beaks and Horns; Jaws that Never Bite; Queer Eyes and Shins—What Purpose do they Serve?

IT is fashionable nowadays to talk as though most of Nature's riddles had been solved. As a matter of fact, nothing could be more false. Take, for example, the so-called lantern-flies of tropical countries. These insects have enormous, hollow processes, projecting forward from the head, which were formerly supposed to emit light after nightfall. We now know that lantern-flies, despite their popular name, are not luminous; that the true fire-flies are really beetles of various kinds.

But what purpose is served by the lantern-fly's enormous beak? Someone has suggested that it is useful as an aid to leaping—the insect being supposed to press the process against the surface upon which it sits, and thus hurl itself high into the air. Needless to say, this is a mere quibble. The problem of the lantern-fly is still unsolved!

In the insect world we find many similar conundrums which vex the soul of the naturalist, who likes to have all his facts cut and dried and classified in pigeon-holes. There are the long-horn beetles. Now the horn, or antennæ, of an insect is known to be an important sense organ—probably acting as a nose, a "feeler," and possibly an ear, all rolled into one. Thus, we should naturally expect it to be well developed. But why, in the name of all that is reasonable, should a beetle possess antennæ that are several times longer than itself—as is the case with the "timber-man" beetle, which occurs in some parts of Scotland, and is common in Lapland and Sweden?

The "harlequin" beetle of South America, shown above, is still more perplexing, for to its long antennæ it adds prodigiously extended forelegs. Another American beetle, a relative of our common May-bug,

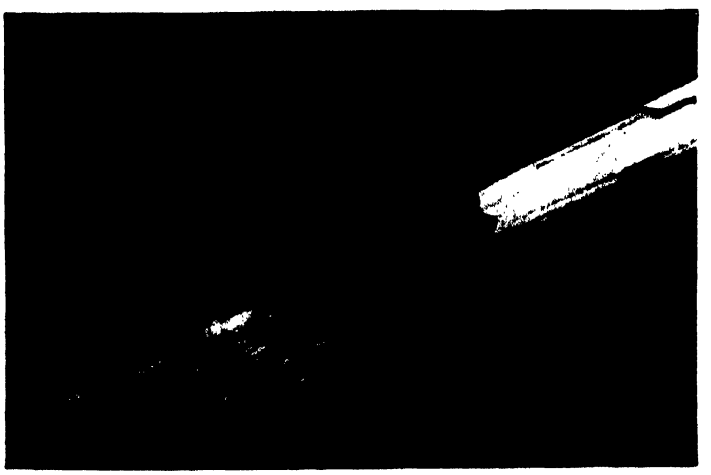
or cockchafer, is endowed with antennæ like great fans, the laminæ of which can be opened or closed at the discretion of the owner. Appendages planned on so huge a scale would seem, *ipso facto*, to be very inconvenient, and science fails to suggest any plausible excuse for their existence. But there they are!

Many other beetles are veritable walking enigmas, and in this respect the males of certain tropical weevils, known as Brenthids, are unsurpassed. Nature seems to have aimed at making these creatures as long and slender as possible, and the reader will admit, after a glance at the photograph on p. 348, that she has achieved no small measure of success. In particular, the insect's head is drawn out into a preposterous nose, or rostrum, near the tip of which the antennæ are carried—the small eyes being situated well to the rear, not far from the spot where the head joins the thorax.

Mexican Chafer Beetle

Observe the huge fan-like antennæ

In his interesting comments on these monstrous creatures, Dr. David Sharp remarks that "the males of some species fight; they do not, however, wound their opponent, but merely frighten him away." This statement is not difficult to credit! But are we to suppose that herein lies the whole significance of the Brenthid's amazing form? Science fails to answer the question.



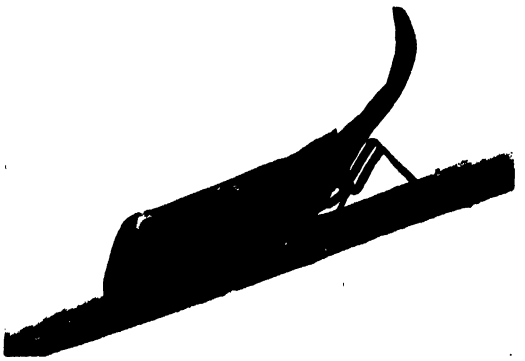
South American Plant Bug

Observe the leaf-like expansions of the shins

Another group of beetle conundrums figures in scientific treatises under the generic title *Mormolyce*. These creatures are not long drawn out, but flat—flat as the proverbial board. Moreover, the head is unusually elongate, and the sides of the wing-cases form large, crumpled expansions which, in their colour and apparent texture, irresistibly call to mind the confections known as "brandy snaps." "These insects (again I quote from Dr. Sharp) live on the underside of fallen trees in the Malay Archipelago and Peninsula; no reason whatever can, at present, be assigned for their remarkable shape."

Scarcely less mystifying are the huge

Insect Conundrums

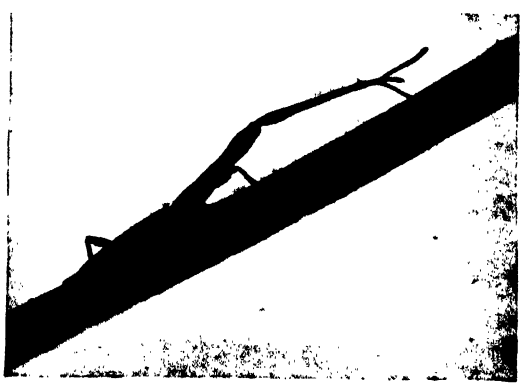


Lantern Fly

What purpose is served by its huge beak?

East African Beetle

Its great forked antler is a puzzle to naturalists



Male Brenthid Beetle

The walking enigma of the insect world

and strangely fashioned horns with which many male beetles are equipped. In a few instances these appendages are known to be used as weapons, or as grasping forceps, by means of which an individual of the opposite sex is carried to a safe retreat.

But one could mention many cases in which the extravagant form of the horns, and their position on the head or thorax, seems to put any theory of practical utility out of court. It seems incredible, for instance, that the African beetle shown in the annexed photograph can *do* anything with the great forked antler which springs from the middle of its forehead—except, perhaps, impede its own progress among close-growing vegetation.

This list of insect conundrums might be extended indefinitely, but four additional examples must suffice. First, we have the stalk-eyed flies, found in tropical Asia and Africa. These curiosities have the sides of the head produced into long stalks, or horns, at the extremities of which are placed the eyes and antennæ. Next, we have a group of tropical American plant bugs, the members of which have the tibia, or shin, of each hind-leg flattened and expanded in a manner suggestive of a leaf. These expansions are invariably prettily coloured.

The interesting genus *Corydalis*, which is represented in northern India and the American continent, comprises some gigantic species of alder-flies, whose males hav enormously developed mandibles that project like horns from the head. Despite their formidable aspect, these huge jaws are never employed for tearing or biting, and their *raison d'être* is difficult to conjecture.

Finally, there are the so-called Seroot flies and their near relatives. They are allied to our own blood-sucking gad-flies, or horse-flies, but differ from them in the extravagant elongation of their piercing proboscis. Only the females possess

this astonishing equipment, for they alone are sanguinivorous. According to Sir Samuel Baker, these matrons render some of the districts of Nubia uninhabitable for about three months in the year. The proboscis is stiff and needle-like; and the fly, while hovering on the wing, is able to pierce the skins of its victims through clothing of considerable thickness. But the perplexing point is this: Why are the trunks of these particular gad-flies immensely long while those of their near relatives (equally bloodthirsty in their day and generation) are short? Nobody seems to know!

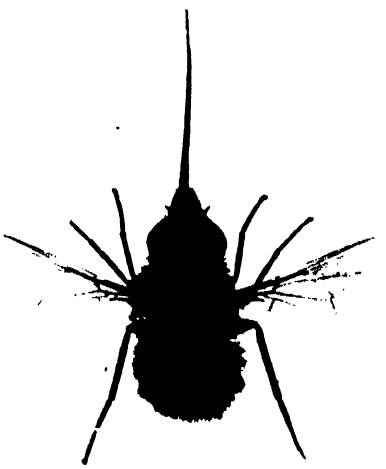
Now there is one possible solution of the problem suggested by the remarkable insects at which we have glanced. They may be products of what is termed "momentum in organic development."

Leading authorities are agreed that living things tend to vary as one generation succeeds another, and that their variations may be beneficial, harmful or merely indifferent. It is believed that those individuals which introduce, as it were, useful novelties in the equipment of their species, have—by the law of natural selection—the best chance of surviving to perpetuate their kind. Conversely, those whose aberrations are directly injurious are most likely to be stamped out. But it would seem that natural selection often fails to operate where variations of no special import are concerned.

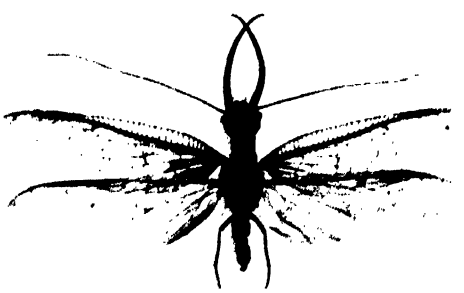
At least, as many readers know, there is much evidence to support the view that one particular structure may continue to grow in successive generations of a species until eventually it can no longer be controlled, and may even lead to the extinction of the race.

It is quite possible that this explanation applies to some, if not all, of the insects which have been described in the preceding paragraphs.

Stalk-eyed Fly
Its eyes are placed at the end of long horns



Seroot Fly
For three months in the year the females render parts of Nubia uninhabitable



Gigantic Alder
Its formidable jaws are never used for tearing or biting

A Colossal Bust in the Great Cave at Elephanta

(Drawn by A. Hugh Fisher)

The central bust, which is nineteen feet high, represents the Indian Trinity, the god Shiva, in his three characters—as Brahma, the creator (in front), Rudra, the destroyer (with upraised hand), and Vishnu, the preserver

Photo Bourne and Shepherd, Calcutta

Interior of the Great Temple at Elephanta

Underground Churches

How Temples and Churches have been Established in the Bowels of the Earth in all Ages

By ERNEST A. BAKER, M.A., D.Lit.
Author of "Moors, Crags, and Caves of the High Peak," &c.

THE frequency of underground churches in the early centuries of Christianity and throughout the Middle Ages was due largely to the veneration in which the worshippers in the Roman catacombs were universally held; but the rites and ceremonies of far older religions had been performed, before the advent of Christianity, in natural caves or subterranean chambers artificially constructed. For the most ancient religions were closely bound up with the sepulture of the dead. As M. Martel points out in "L'Evolution souterraine," the oldest historic religion, that of the Egyptians, placed its cemeteries and sanctuaries underground, guarding the mummies of the Pharaohs with the labyrinthine corridors beneath the pyramids, consecrating grottoes to that hallowed reptile the crocodile, and constructing the colossal underground temple of Abu-Simbel and others in Nubia, filled with treasures of art that have remained to this day. Throughout Asia, also, subterranean temples abound. They are found in Thessaly in European Greece, and Cilicia in Asia Minor; but the most magnificent are those of India and Ceylon. At Elephanta, an island in the harbour of Bombay, there is a wonderful temple cut in the rock, dedicated to Siva, and adorned with sculptured figures of Brahma, Vishnu, Siva, and other Hindu deities, forming the most important memorial of the ancient religion of Hindustan. It dates from about the tenth century B.C. Both in Western Asia and Egypt, the fashion of cutting places of worship in the depths of the rock—often

planned on elaborate architectural lines—and decorating them with sculpture in the living stone, persisted long after the Christian era.

It was not only at Rome that the early Christians sought an asylum for the practice of their religion in catacombs. Those at Naples and Syracuse—of much nobler dimensions than the Roman catacombs—of many other towns in Italy, Spain, France, Germany, and some of the Mediterranean islands, were likewise utilised for divine worship. Many of these subterranean necropoli—for they were originally places of sepulture, or at any rate consecrated to that purpose after being used as quarries—were of vast extent. It has been computed that the Roman catacombs, if stretched out in a continuous line, would reach from end to end of the Italian peninsula. They were also richly adorned with paintings, for wealthy citizens had their family vaults there; and, furthermore, these were the shrines in which the whole elaborate ritual of Christian worship was carried on for generations.

The martyrs of ancient Gaul were interred in subterranean mausoleums, like their brethren of the Roman catacombs, and often a church was erected over their heads. Hence arose the practice of preserving the relics of saints in the crypts of churches, which became universal throughout Christendom, the crypts becoming the resort of hosts of pilgrims. A familiar instance in this country is the crypt of Ripon Cathedral, which was constructed by St. Wilfrid in the seventh century A.D., and still remains in good preservation under the Norman church. Wilfrid had visited Rome and seen the catacombs, and he modelled both this crypt and the one beneath his church at Hexham on the cubiculum adjoining the cemetery of St. Calixtus, in which the bodies of the apostles Peter and Paul are supposed to be interred. Religious services are still conducted in the crypts or under-crofts of our cathedral churches, a most interesting example being the one established in a chapel beneath the south transept of Canterbury Cathedral by Queen Elizabeth

Drawn by F. de Haenen

The Grotto of the Nativity at Bethlehem

In a crypt beneath the Church of the Nativity, a shrine occupies the site which tradition states to be the actual place where Jesus was born. Observe the two entrance staircases, one for the exclusive use of Latins, the second for other sects

for French Huguenot refugees, which is still kept up every Sunday afternoon.

The same conditions that gave rise to the cave-villages of central France, mentioned on page 85 *et seq.*, led naturally to the construction of underground churches, hollowed out of the chalk or some other rock easy to excavate. Of these the most impressive in point of size and a kind of majestic simplicity is the monolithic church of St. Emilion in the valley of the Dordogne. This structure has a total length of 120 ft., the front portion being a vestibule or ambulatory 20 ft. high, with traceried windows in the flamboyant style, and a doorway richly decorated with sculptures. Inside this are a nave and aisles, cut out of the solid rock, soaring to a height of 60 ft. All the light comes from one end, through the windows of the vestibule and three others above it, so that the choir arch, in which two colossal figures of angels are carved, and the choir itself are seen in a most impressive twilight.

At Aubeterre in Charente there is a somewhat similar but smaller church hewn out of the chalk, consisting of a nave and one aisle, separated by massive columns, the whole much neglected and in a rapid state of decay. At the far end an apse is hollowed out of the rock, and here stands the tomb of the feudal lord of Aubeterre, François d'Esparbes, an imposing piece of Renaissance work, with pillars and arches all cut from a solid mass of chalk. From above the arch, opening into the apse, runs a gallery, leading to a kind of elevated pew high over the entrance, where the family of the Marshal of Aubeterre, François d'Esparbes, assisted at divine service. The Marshal was a Huguenot, and cleared

Drawn by L. de Haenen

The Cave of the Nativity

The picture shows the Patriarch before the effigy of the infant Jesus at Bethlehem. Of the fifteen lamps in the recess, 6 belong to the Greeks, 5 to the Armenians, and 4 to the Latins

away every symbol of the Catholic religion. Aubeterre itself was a Huguenot stronghold, and defied many assaults by the Catholic soldiery during the wars of religion.

There are small churches or chapels hewn out of the rock at Rocamadour, at Lirac in Gard, at Caudon in the valley of the Dordogne, and at many other places in France.

Natural caverns were also used for worship, especially during the religious troubles.

Natural Caverns as Churches

The Calvinists used one near Nimes before they gained possession of the town; another near Rocamadour did duty for the parish church until this was rebuilt. All the hermitages carved in the rock in many parts of Europe were places of worship, and often favourite places of pilgrimage. The monastery in the soft sandstone at Nottingham, and the anchorites' cells and chapels in the neighbouring county of Derby, have been referred to on page 90.

Even mines have served at various periods as places of worship. As mentioned on page 160, services are held in the salt mines of Austria, vast excavations as impressive in their mere dimensions, strangely adorned by Nature with marvels of glistening crystal, as the finest underground temples made by man.

The vestibule of St. Anthony's Chapel, which was hewn in the solid salt more than two centuries since, consists of a symmetrical archway with figures at the sides. Within there is an altar, above which is a representation of the Crucifixion, and on the steps of the altar are the forms of two kneeling monks. On the sides of the chapel may be seen smaller altars and statues of saints, all carved out of salt. Many times each year the priests of the district perform their pious duties in this simple chapel, not only in memory of St. Anthony himself, but as a tribute to the miner who, unaided and persevering, carved the chapel as it stands to-day.

Hard by St. Anthony's Chapel the torch of the guide illuminates a magnificent shrine and archway hewn in one of the passages. Again, as we move along, we see figures of saints in the attitude of prayer, and a few minor rooms, which we pass hurriedly through, bear the name of martyrs. The Queen's Chapel, with its fine altar, contains on one of its sides a view of Bethlehem. Tradition has it that one man spent many months of silent effort on this picturesque sculpture, now shown to every visitor as one of the lesser but interesting curiosities of the mines.

But in the depths of the earth, even without the accompaniments of natural scenery or Christian art, the mere act of worship cannot fail to stir the imagination. During the Singing Revival in Wales in 1904–5, many a religious service was held deep underground by the colliers of Pontypridd and Merthyr Tydfil. In his "Mouvement mystique contemporaine," an interesting study of this famous revival and of the career of the evangelist, Evan Roberts, M. Rogues de Fursac describes one of these meetings, which took place at six o'clock one morning in a working nearly a thousand feet below the ground. Arriving at the bottom of the shaft, he was conducted along a gallery to a spot where a congregation of miners had assembled. "A few were gathered into a small group; the rest, mostly sitting on stones or pieces of timber, some on their knees, were ranged in two lines along a gallery to the right, each with his little lamp before him. The silhouettes of the men were gradually lost in the darkness; a few dozen yards away the eye could see nothing but their lamps, giving the idea of a line of luminous points. I was invited to sit down on a beam, and prayer commenced at once. First they chanted the 'Dyma Gariad fel y moroedd.' Whilst the deep tones resounded along the vaults little groups of miners arrived at regular intervals and took their places away there in the darkness, at the extremity of the files. All these men, those who were

In a Coal-mine

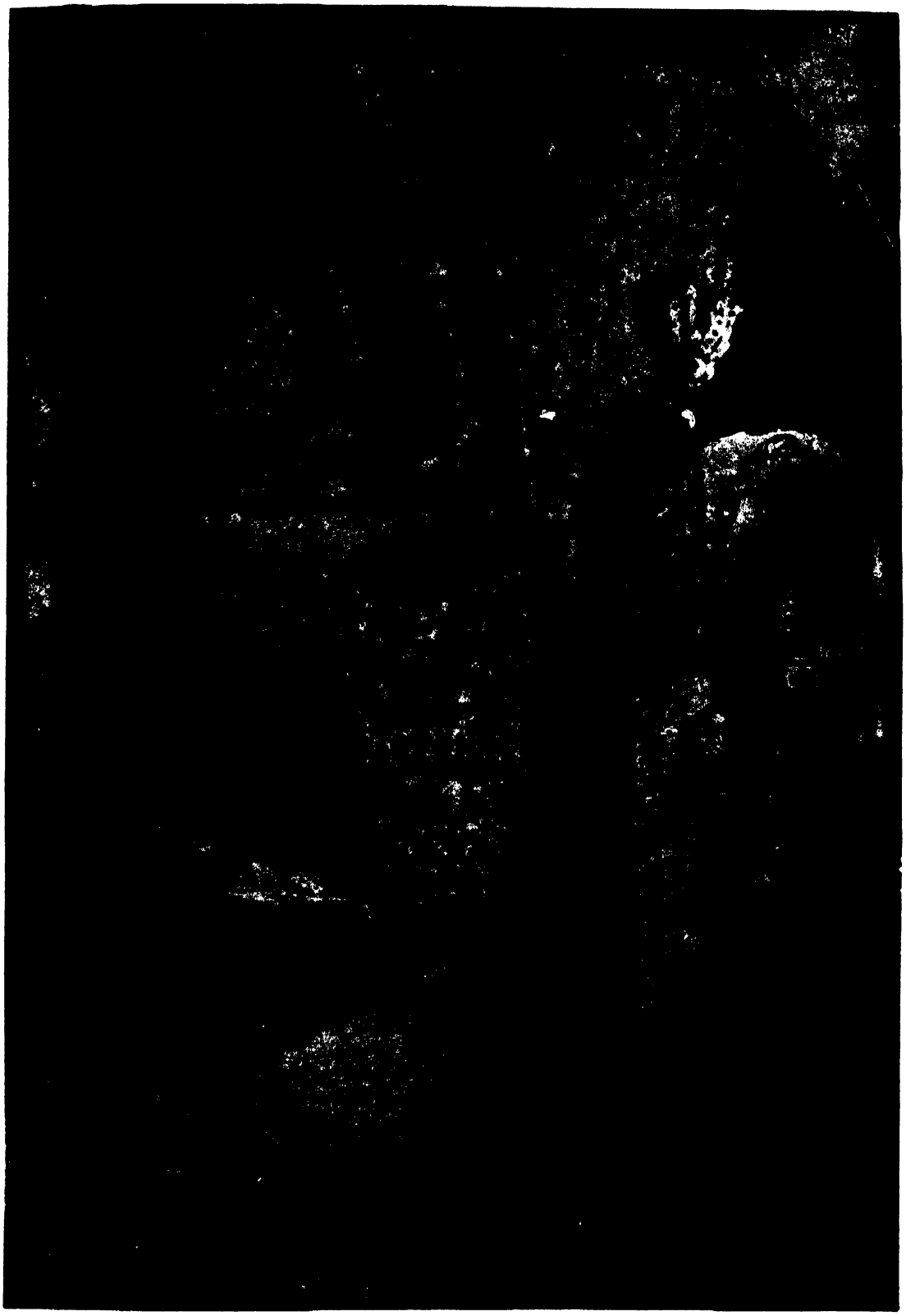


Photo: Underwood & Underwood

A Corridor in the Catacombs at Rome

It has been computed that the Roman catacombs, if stretched out in a continuous line, would reach from end to end of the Italian peninsula

moving, like those who prayed, were surprisingly serious. Doubtless the religious atmosphere prevailing here has much to do with this. Perhaps, also, there is in the minds of these men a subconscious feeling of the invisible danger ever on the watch, and the sense of gaining their bread hundreds of men standing there, so composed and resigned, were not come there for some frightful hecatomb like that which, a few months ago, had overwhelmed their comrades at Courrières. A final hymn is sung, the meeting is at an end. The files disperse, each departs to his task; the

St. Anthony's Chapel, Wieliczka

This strange church, hewn in the solid salt, deep below the surface, has been a place of worship since 1698. The photograph cannot convey any idea of its beauties—due to the glistening of its walls and carvings of gleaming salt

not only by the sweat of their brow like all the sons of Adam, but at the peril of their lives. To the hymn succeeds a prayer, then another, the latter said by an aged miner and peculiarly striking. He called down the divine blessing on the labour of the day. He asked God to preserve the miners, to keep far off the scourges of the coal mine—sudden floods and the terrible firedamp. These simple words gave the scene a poignant character, and made one wonder with an aching heart whether these horses, as resigned as the men, come up to be harnessed to their trucks, and the mine resumes its activity of a subterranean hive. I chat for a moment with a few miners; then I regain the surface.

"Reaching the town, I buy a paper offered me by a small boy. My eye is caught by a headline in huge print—'Terrible accident in a Glamorganshire mine; men surprised by a flood; 2 saved, 6 drowned.' And the touching prayer of the old miner sounds anew in my ears."

Photo: R. P. Holloway, St. John's, Newfoundland

This Iceberg may have taken a Century to Grow

The Birth and Death of an Iceberg

Concerning the Slow Self-Destruction of a Frozen Sea-City

By N. F. WATSON

IT is born in the gentle, sportive snowflake; it forms a glacier which rips the ribs from a mountain side; it launches itself, a sea-going city of ice, and rides an ocean current into latitudes where the man-made cities steam; it crushes a whaling fleet, or rives open our greatest liner, and drives, in placid brutal omnipotence, on to mysterious suicide. Such, in brief, is the biography of an iceberg. When the great *Titanic* sank, shattered, into her everlasting tomb, poetic fancy conjured up a vision of the simultaneous rising into shape of the two mighty forces which met, with such catastrophic effect, that tragic night in the North Atlantic. The calculation was probably all wrong. The wrecker of the *Titanic* was formed, it is likely, before ever the first steamship was launched. An iceberg may have been a century and more a-building before it takes the sea.

The icebergs of the Atlantic issue from the frozen North. Moisture reaches the mountains and highlands of Greenland and Spitzbergen, in the form of snow. Snow upon snow—year after year, age after age—that is the raw material. Ice and snow lie 10,000 feet deep in the Arctic. If the accumulation continued unchanged the snowfield would out-top the clouds. But snowflakes in bulk assume great weight. Those below, pressed down by the weight of the ever-growing burden above, become gradually hardened. The air is driven out, partly by pressure from above, partly by the slow movement imparted by gravitation. And the snowflakes become ice—hard, solid blue ice—ice which forms the glacier, and, for all its immensity and apparent immobility, moves, flows like fluid. Nature never hurries, and the transition from glacier to iceberg is slow. It has been shown by Agassiz that the ice masses of the Aar

glacier in the Bernese Alps, require 183 years to perform their descent from summit to inferior extremity—a distance of only ten miles. With equal deliberation the glaciers of Greenland slowly grind their way down the mountain valleys to the coast. And there, in due season, the glacier thrusting out into deep water, the buoyant water imparting a constant upward stress, four St. Paul's Cathedrals, placed one on top of another. As an iceberg—though so much lighter than water that it floats—rides with only a seventh or eighth of its substance above the surface, it is fairly safe to assume that a monster such as this, before its massy heights were thawed and fractured into spires and pinnacles, would have total height of some thousands of

Photo: R. P. Holloway, St. John's, Newfoundland

A Mighty Ice Island

Icebergs have been surveyed whose proportions showed a content of 2,000 million tons—sufficient to make over 330 Great Pyramids

the entire front of the ice-wall breaks away.

An ice mountain takes the sea, a structure in comparison with which the mightiest work of man's hands is puny indeed. The colossal Pyramid remains our greatest yet, with its six million tons of material; icebergs have been surveyed, whose proportions showed a content of 2,000 million tons—sufficient to make over 330 Great Pyramids. We have records of icebergs whose pinnacles towered 1,500 feet above the sea, a height equalling that of feet. The area of icebergs varies greatly, of course, but bergs measuring from two to two-and-a-half miles in length, and much the same in width, have been frequently recorded. At a distance they present the appearance of snow-clad islands. But they have this difference, that they travel —in such a fashion as to strike terror into the heart of the mariner.

Before the invention of the steamship, it was impossible for navigation to be effected save by the aid of wind or tide. The iceberg moves at times across the

ocean in seeming defiance of natural laws. These ice cities may be seen gliding, mysterious and sinister, across the waste of waters, in the teeth of a raging gale and in opposition to the flow of the surface current. Need we wonder that ancient mariners associated the iceberg with powers supposedly derived from infernal sources? The explanation of this apparent upset of all rules and regulations is in reality simple. There is a tide in the affairs of ocean which is not visible on the surface. Deep beneath the crest of the waves, under-currents or drifts are moving inexorably on from the icy North to cool the waters of the Tropics. And, the vast bulk of the iceberg being immersed at great depth, the whole is propelled by this powerful under-current

Wind and surface-flow act upon only an eighth of the berg; the drift below has seven-eighths of the ice-mass upon which to exert its force. Hence the berg would advance where ships lay becalmed, or crush the ship which sought to escape by the aid of a rising breeze. The under-current is there for the vessel as well as the berg, but it must be sought hundreds of feet down. And that way lies the Port of Lost Ships. When they can, men avoid icebergs as the very emblem of disaster and death, but one man wooed a berg with ardour—and success. Dr. Kane, the American voyageur, who gave many years to exploration in search of the lost Franklin Expedition, lacking steam, hitched up, when in danger, to an iceberg, and travelled as never ship was permitted willingly to travel before, at the heels of an iceberg, due north, when wind and tide conspired to drive him in the opposite direction. But it is not at the service of man that the iceberg sets out to sea. It is his enemy, which sinks his ships and takes toll of life as fearfully as a cyclone.

Ice Architecture

Snow upon snow—year after year, age after age—such is the raw material of the iceberg

Photo: R. P. Holloway, St. John's, Newfoundland

A Yacht of Gleaming Ice

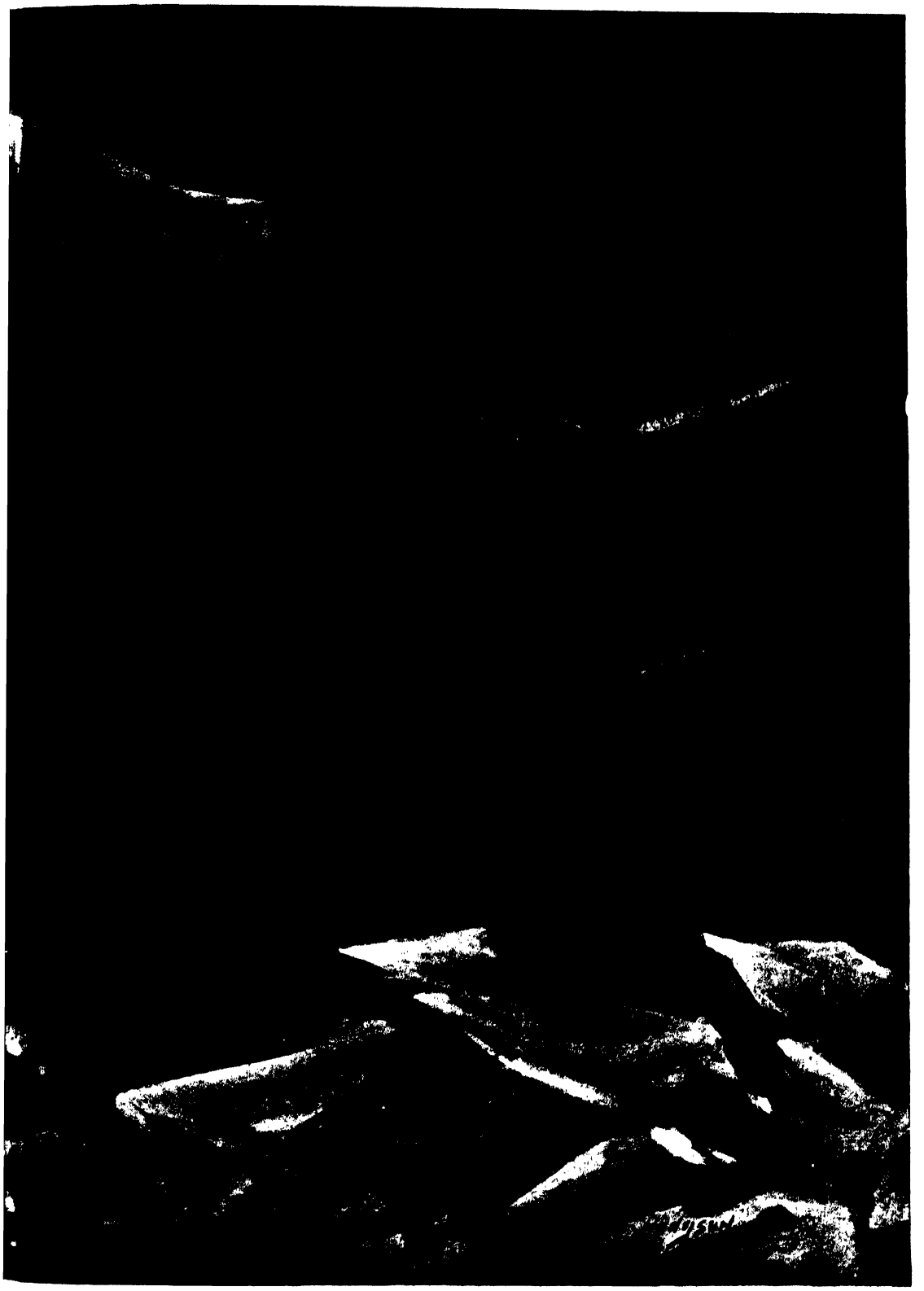
An American explorer once escaped grave danger, when his ship lacked steam, by making an iceberg tow him against wind and tide

That it is not more destructive, we owe to twin romances of the natural system. In the first place, if ice did not float, our rivers and seas would be rendered solid by its sunken masses in time. In the second place, water, when about to become ice, expels all

THE PORT

(Dr

The iceberg moves at times across the ocean in seeming defiance of natural laws. Ice cities glide, mysteriou which propel a ship. The explanation is that the berg is propelled by under-currents hundreds o



LOST SHIPS

E S Hodgson)

sinister, across the waste of waters, in the teeth of a raging gale and in opposition to the flow of the surface currents down, which will drive it on to meet and crush a ship propelled by wind and surface currents to meet it

its impurities, salt among them. Now all the great bergs are children of the mountain and begotten of the snows. But there are vast fields of ice from sea-water, the ice that fills the fiords and bays and inshore waters of the frozen lands. This contains very little salt, and that in the main mechanically held. Such ice, upon melting, yields, therefore, practically fresh water. The safety of navigation depends upon this little fact that icebergs, as they thaw, release sweet, not salt, water.

An Iceberg's Suicide

It seems a trivial thing, yet it is absolutely vital to the safety of sea-going humanity. For the mightiest berg that ever broke out of the hoary North, contains within itself the instrument for its own undoing. The frigid leviathan, staggering unsteadily across the deep, cannot be destroyed by human agency; it overwhelms its would-be destroyers. Nevertheless it goes slowly on to suicide.

From the time it leaves the land from which it is launched, the iceberg slowly dies. But it does not dissolve into the sea as simply as a pyramid of salt dissolves in water. There is the strangest phenomenon associated with its dissolution. Ice, it has been shown by Dr. Otto Pettersson, when melting in salt water, produces three distinct currents.

1. When the ice melts it cools the salt water, which sinks down by convection.

2. A stream of warmer salt water moves in towards the iceberg, to take the place of that which has sunk, and so gives rise to a horizontal current.

3. The melted ice consists of fresh water, which, through difference of density, does not mix with the salt water. This fresh water rises upon the surface of the water around the iceberg, and spreads out on the surface. The iceberg is thus surrounded by a layer of fresh water, which follows the berg as it travels.

The effect of this is very striking. The water by which the berg is surrounded, becomes, not colder, as we might expect, but warmer. Fresh water, being of less density than salt, more readily absorbs heat from the sun, absorbs it rapidly, and retains it. Thus the berg is encircled by a sort of warm bath of its own creating. The fresh water, streaming in cascades down the sides of the berg, does not readily mix with the sea, but floats upon the salt water, as oil floats upon clear water. And that constantly increasing layer of fresh water, given off by the berg, becomes in time the winding sheet of the ice island, whence it is derived. The more the berg thaws, the more rapidly is it induced to continue the process, for the greater becomes the volume of warmed fresh water around it. The process of dissolution proceeds above and below the surface level. Fanned by the breeze, warmed by the sun, the crystal leviathan converts its precipitous massive sides into rivulets of running water. This water remains to become heated by the sun and atmosphere, and to constitute a hot blanket around its parent. Thus, though the iceberg carries death to man and annihilation to ship in its lumbering course, it carries also the means for its own dissolution within itself. Sometimes the disintegrating process, proceeding rapidly in the deeper strata of the warmed fresh water, shifts the centre of gravity, causing the berg to rock and finally overturn, when, if a ship be near, the floating monster, like blind Samson, wreaks, in its own downfall, ruin and death upon all within reach.

Puzzling Phenomena

The sinking of the *Titanic* by an iceberg has directed attention anew to the peril of ships from these greatest of Nature's battering rams, and Professor Howard Barnes, a distinguished Canadian scientist, has carried us far in understanding these puzzling phenomena. He enables us clearly to understand how it is that upon first approaching the vicinity of an iceberg, the mariner records a rise in water temperature, as explained above.

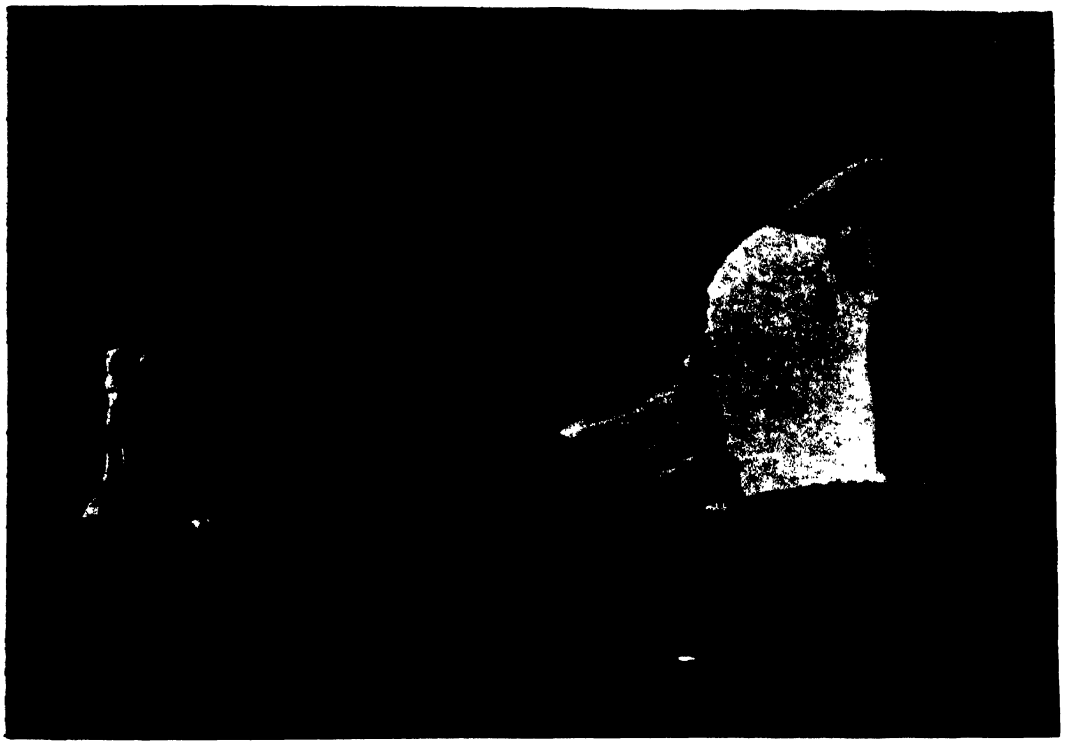


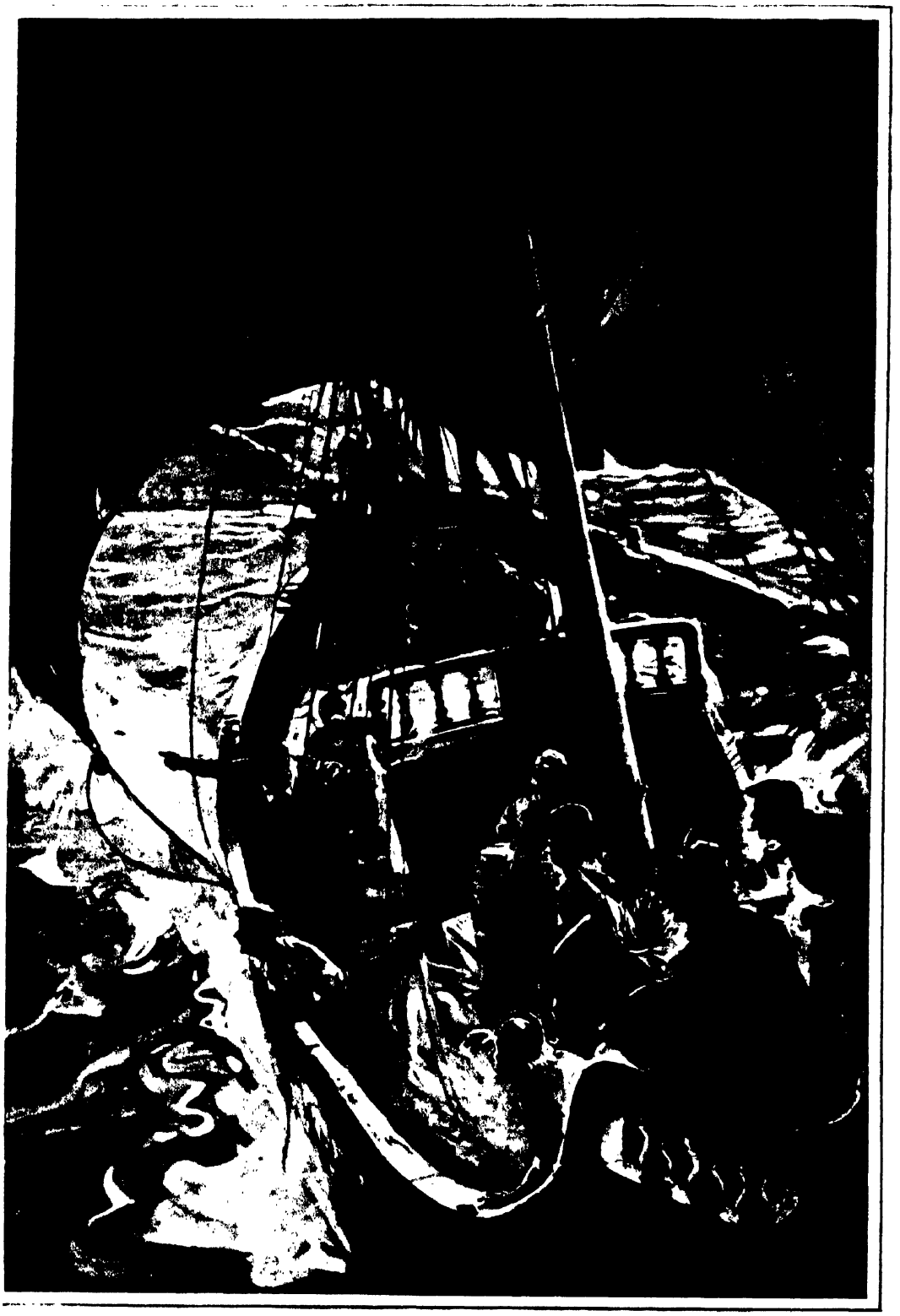
Photo R. P. Holloway, St.

A Mighty Berg, the Dread of every Mariner

Photo: R. P. Holloway, St. John's, Newfoundland

The Fantastic Remnant of a Leviathan Ice-City

Though it cannot be destroyed by human agency the mightiest berg inevitably commits suicide. From the time it leaves its land of origin it slowly dies, dissolved in a bath of warm water of its own creation



Bartolomeu Diaz Rounds the Southernmost Point of Africa

The Portuguese reached the estuary of the Congo by 1482, and finally had rounded the Cape of Good Hope by 1485. It was Bartolomeu Diaz who accomplished this great feat, and it was King John of Portugal who named this promontory for all time "the Cape of Good Hope"

The Great Discoverers—II

How Man has Triumphed over the Ocean and other Natural Barriers and Discovered the World

By SIR H. H. JOHNSTON, G.C.M.G., K.C.B.

THE result of the stimulus provided by the Moorish travellers of 1415, who interested Prince Henry of Portugal in Western Africa, was not only that the Portuguese soon after discovered Madeira and colonised the Azores and laid hands on many points on the Morocco coast, but that they passed one stormy headland after another till they had rediscovered the river Senegal, rounded Cape Verde, found the Cape Verde Islands far out in the Atlantic, had reached the Gold Coast, verified the stories of West African wealth in gold, discovered the strange civilisation of Benin and the mighty coast volcano of the Cameroons. They reached the estuary of the Congo by 1482, and finally had rounded the Cape of Good Hope by 1485. It was Bartolomeu Diaz who accomplished this great feat, and it was King John of Portugal who named this promontory for all time "the Cape of Good Hope."

Bartolomeu

His "good hope"—and a well-founded one—was that Portugal had discovered the sea route from Western Europe to India. Vasco da Gama proved this fact by sailing round South Africa and up the east coast to Zanzibar and Somaliland in 1498; thence passing across to the west coast of India.

Before many years had followed, the Portuguese navigators had placed Madagascar and the Mascarene archipelagoes on the map, had explored the Red Sea and got into Abyssinia, surveyed the south coast of Arabia and the whole coast of India from the Persian Gulf to the Bay of Bengal and Burma; had similarly revealed—not to the world but to their own secret archives—the Islands of Ceylon, Sumatra, Java, Borneo, and all the rest of the Malay Archipelago as far east as the Moluccas and as far north-east as Celebes. But whilst and after they were doing this an even greater rival in geographical revelations appeared on the scene—the sister nation of Spain—as we loosely call it—in those days of the joint kingdoms of Castile and Aragon. Here the stimulus came from Genoa. The Genoese, often baulked in their projects for a world empire by the rivalry and hostility of Venice and Pisa, but who had nevertheless revealed the geography of the Black Sea and of much of Asia Minor, and had led the way in Central Asian discovery, approached the King and Queen of Castile and Aragon with the project of finding a route to India across the Atlantic.

Columbus, a Genoese, had conceived this project for years, partly no doubt through his relations, as a pilot, with earlier explorers who had gleaned stories of the Norse discovery of Greenland and Nova Scotia (for example, through Zeno the Venetian). By this time the renascence of learning was well established in Italy, and the work of the Greeks and the Graeco-Romans, abandoned under the benumbing influence of Byzantine Christianity (*see* p. 28) had been resumed.

Christopher Columbus

The earth was conceived of as a round globe, and, this being the case, it was

obvious that if India lay to the *east* of Arabia and Persia (it had by this time frequently been reached by Italian and German explorers) it must lie to the *west* of Spain. The extraordinary travels of the Venetian brothers, Niccoló and Maffeo Polo, and their still more remarkable son and nephew, Marco Polo, had carried European knowledge as far east as China and as far to the south-east as Malaysia, with a hint perhaps here and there of some great civilisation beyond, like that of Japan ("Cipangu").

Colombus, therefore, was agog to reach this wonderful Cipangu; and the lands of Cathay, with their silk, their scented woods, and their dyes; and the wealth in gold and ivory of India. After many checks and disappointments this project was taken up by Spain; and in 1492 his ships reached the little island of Guanahani in the Bahamas archipelago of the northern West Indies, and thus discovered the New World. For some years afterwards Columbus and the great Spanish explorers who followed him, still groped their way past these disappointing though exquisitely beautiful and fertile regions peopled mainly by savages, yearning to find the emphatic civilisation of the Far East. But wherever their sailing-vessels penetrated they were always barred sooner or later by a continuous stretch of land.

At last one of these adventurers (Vasco Nunez Balboa), guided by Amerindian savages, found his way across the Isthmus of Panama to an altitude from which he gazed over a limitless ocean, the Ocean of the South, as it was named for a long time to come; for as Central America lay in a nearly east to west direction, the Atlantic seemed to be the northern and the Pacific the southern ocean. In 1539–41, Francisco de Orellana led an expedition from Peru, which traced the mighty Amazon River from near its source in the Andes to its mouth in the equatorial Atlantic.

Vasco Nunez Balboa

How to find the way round these huge continents of North and South America was the next problem. It was suspected that there might be both a north-west and south-west passage. The explorer Magellan (he was a Portuguese in reality, and his name properly spelt was Magalhães) passed southwards along the east coast of Brazil, Argentina, and Patagonia, until he discovered the straits named after him. A little farther to the south and he would have rounded the South American continent altogether, a feat not to be accomplished till some years afterwards by both Francis Drake and the Dutch seamen.

Magellan

But the advantage of the Straits of Magellan was that vessels of that day avoided the appallingly rough seas which lashed the coasts and islands of Tierra del Fuego. Magellan, emerging on the south coast of Chile, steered northwards for some distance, and then boldly turned the prow of his vessels once more westward, and so sailed with great celerity across the broad waters of the Pacific, first of all reaching the outskirts of Eastern Asia at the island of Guam.

Thence he proceeded on his course, avoiding as much as possible the islands already discovered and settled by the Portuguese, till he reached the Philippine Archipelago, where he encountered a rather highly developed Malay civilisation, influenced no doubt by China. He lost his life in a treacherous attack on the island of Sebu (in the Philippines); but one of his vessels after many narrow escapes, actually rounded the Cape of Good Hope and reached Lisbon, having made the first complete circumnavigation of the globe.

This was in 1522; and jealously as Spain (and Portugal) guarded their secrets of discovery, the fact was so amazing and glorious a one that it could not, out of national vanity, long be kept secret. In course of time it penetrated to English

Sir Francis

minds and stimulated gallant seamen like Drake—giants in intellect and imagination, men of the twentieth century like Shakespeare, living long before their appropriate time—and they not only yearned to do likewise, but to add to the sum of discovery.

Spain had plunged into war with the Protestants of the Netherlands. Even before this political blunder on her part, the Flemings, Dutch, and Frisians of these Burgundian possessions had proved themselves very valuable coadjutors of the Spaniards in discovery and colonisation. Consequently, they knew, as it were, all the secrets of the Indies and America, and when Spain fell out with them they proceeded to avenge themselves by navigating all the oceans of the globe where they could either attack Spaniards or Portuguese or found rival trading-stations.

The rôle of the Dutch in geographical discovery was a most important one. The British and the French had led the way as regards South Africa, India, Malaysia, South America, the West Indies, and the Arctic regions; but the Dutch followed quickly in their tracks and often outdid them. It was Dutch seamen (Jacob Le Maire and Schouter) who really solved the geographical problem of the extremity of South America; it was Dutchmen such as Abel Janszoon Tasman who discovered the north and west of Australia, the islands of New Zealand, and several Pacific islands or archipelagoes.

Dutch and Spanish Navigators

The Dutch (and later the French) increased and extended the Portuguese explorations of Eastern Asia until at last they reached the Aleutian archipelago. The Dutch colonised South Africa in the seventeenth century, and under their influence or through them the Orange River and the Limpopo were placed on the map. The Dutch also greatly added to our knowledge of West Africa, where they founded important colonies. It was, however, Spanish explorers in the late sixteenth century (Mendaña de Neyra, de Quiros, and Vaez de Torres) who completed the sketching out of the Malay Archipelago. They discovered the New Hebrides, the Solomon Islands, and New Guinea.

In the seventeenth century Russia awoke to civilisation and a longing to extend the White man's influence over the Eastern world. Russians revealed the north coast of the great Asiatic continent and its peninsulas stretching out towards America. It was a Dane in Russian employ who actually revealed the sea passage Behring'sStraits between Alaska and Siberia. Siberia itself is named after the Russian explorer Sibir. Frenchmen did much during the same period to clarify the geography of Persia and of India, of West Africa, Brazil, China, and Indo-China.

Russian and French Discoveries

The eighteenth century was one of the great periods of far-reaching exploration, an exploration, moreover, which now definitely entered on the scientific stage with a careful fixing of latitudes and longitudes, of altitudes and temperatures; a scientific examination of fauna and flora, of languages, habits, and customs of strange peoples. Much of the best class of travel book published in the eighteenth century might easily have been published in the nineteenth, and is even valuable in the twentieth.

Perhaps it may be said without injustice to others that the great rôle in the eighteenth century was played by English and Scottish explorers. Noteworthy amongst these was the great James Cook, the son of a Yorkshire labourer, the apprentice of a collier, but "a born gentleman," and one who by assiduous study made himself a man of science. James Cook revealed to us almost all the secrets of the lands in the Pacific. He mapped the eastern half of the Australian coastline. He definitely placed New Zealand on the map, as well as Easter Island, New Caledonia, the

James Cook

Hawaii Archipelago, Tahiti, the Marquezas, the New Hebrides, New Britain, and New Ireland (once more restored to the British flag in 1915), and parts of New Guinea. Almost the only portion of land in the Pacific which he did not actually visit or realise was the comparatively large archipelago of Fiji.

Cook really led the way in Antarctic discovery, and gave the first indications of the limits (more or less) on the north of the Antarctic ice-fringed continent. Cook likewise took a great step toward the definition of the North American continent by passing through Behring's Straits into the Arctic Ocean and rounding the north coast of Alaska. His work in regard to Alaska and British Columbia then an absolutely unknown region was continued and amplified by Captain Edward Vancouver.

In a very different quarter of the world other great discoveries were being made by British subjects. James Bruce, after adding greatly to our knowledge of the geography of North Africa, revealed virtually the whole course of the Blue Nile, tracing it from its source, in Abyssinia, to Khartum. At the close of the eighteenth century equally wonderful feats were achieved. Alexander Mackenzie crossed the North American continent at its broadest and carried the British flag from Eastern Canada to opposite Vancouver Island, where he actually came into contact with Vancouver's maritime discoveries.

Other British Discoverers

Of course, a great deal of the interior of the Canadian Dominion and what are now the United States had been made known by French pioneers in the sixteenth, seventeenth, and early eighteenth centuries—Jacques Cartier, Samuel Champlain, the Chevalier Du Lhut, Lasalle of the Mississippi, and the La Vérendrye brothers, who discovered the Rocky Mountains. Henry Hudson, an Englishman, had been the first to enter Hudson's Bay in 1610 (and had died there). Englishmen and Scotsmen —notably Samuel Hearn—had in the eighteenth century revealed the main facts of geography in Northern and Arctic Canada.

In 1798 Mungo Park, another Scotsman, reached the upper Niger from the Gambia coast and definitely revealed a great fact in African geography.

A little earlier Tibet had been explored by a Dutchman, Samuel van de Putte, and by an even more remarkable English traveller, George Bogle.

In South America it was naturally Spaniards and Portuguese who led the way in discovery, since they were the political masters of that continent. In voyages of thrilling interest and amazing adventure the main courses of the Orinoko and the Amazon Rivers from the frontiers of Colombia and Peru to the Atlantic Ocean had been laid down by Gonzola, Pizarro, Orellana, Lope Aguirre, and Iago de Ordaz. But a good deal of scientific South American geography in the eighteenth century was due to French travellers like La Condamine, and at the close of the eighteenth century the educated world read with intense interest—an interest which still exists—the travels of von Humboldt, a German professor.

S. American Discovery

At the opening of the nineteenth century except in the direction of the Arctic and Antarctic regions, the only important portion of the earth's surface as to which virtually nothing was known by the civilised people of the world, was the interior of Africa. The main features in Asian geography and even in South America and North America, had been laid down; and all the Pacific archipelagoes and islands of any importance, except Fiji, had been indicated on the map.

The progress of African discovery in the nineteenth and twentieth centuries will be dealt with later (*see* pp. 766–769).

At the very beginning of the nineteenth century the Australian continent had been

circumnavigated by one of the greatest, bravest, and least appreciated of pioneers — Matthew Flinders – an officer of the British Navy. He died in 1814, of a broken heart (leaving a destitute widow) through the sheer ingratitude and stupidity of the British Admiralty. His grandson, Professor Flinders Petrie, would probably not have come into existence or survived to be the first amongst Egyptologists had it not been for the generosity of the new-born State of New South Wales, which did what the British Government of its day should long before have done – granted a pension to the widow of the first circumnavigator of Australia.

Explorers of Australia

Following not long on Captain Cook's discoveries, the south-east coast of Australia was colonised by Great Britain, and, after its circumnavigation by Flinders, the inner exploration of the continent proceeded vigorously, stimulated as it was first by the discovery of rich pasture lands and good forest, and later by the presence of alluvial gold.

The great pioneers in the land discovery of Australia were Blaxland, Wentworth, and Lawson (the Blue Mountains); Captain Charles Sturt, Edward John Eyre, Dr. Leichardt (South and Eastern Australia); M'Donald Stuart, O'Hara Burke, and W. J. Wills (Central Australia), and Egerton Warburton, Sir John Forrest, and Ernest Giles (Western Australia). Dr. H. O. Forbes assisted to reveal the fauna and flora of Timor, and to explore the lofty mountains of British New Guinea; and Alfred Russel Wallace in the middle of the nineteenth century made the first really scientific exploration of the fauna and flora of Malaysia from Sumatra to Papuasia.

Photo by permission of the Western Australian Tourist Bureau

A Camel Caravan in Western Australia

Pilot-Whales or Blackfish

From the tails of fish man has taken the design of the screw propeller; the shape of the whale has also been taken as a model by builders of submarines

Nature as Inventor

How Man has Gone to Nature for the Original Model of many of his most Useful Inventions

By S. LEONARD BASTIN

Author of "Wonders of Plant Life"

IT is often said that there is nothing new under the sun, and in no direction is this so true as with human invention.

Brief examination shows our cleverest devices to be but copies (and often rather poor ones at that) of things which were originated by Nature countless ages ago. Some of the most interesting of these have been collected, both from the animal and from the vegetable kingdoms.

The screw propeller as applied to ships is a comparatively modern invention, yet, as a means of forcing a body through the water, the idea is as old as the hills. Anyone who has watched the movements of a gold-fish in a globe will realise that, in the tail of the creature, we have a perfect example of the principle of the screw propeller. The forward movement of the fish is entirely accomplished by the twisting movement of the tail from side to side. It is, of course, the force with which the sides of the tail press against the water that gives the impetus, and the same principle is demonstrated in the working of the propeller. The only difference in method is that the propeller revolves continually, whilst the tail is simply swished from side to side.

Nature as Inventor

In Arctic expeditions some of the most valuable appliances are the various kinds of ice-anchors and hooks. These may be used for a large number of purposes, such as mooring boats against ice floes, or for securing a hold on the slippery surface. Now the early explorers were rather staggered to find that natural ice-hooks were extensively used in the Arctic regions. There were, of course, excellent opportunities for studying the habits of the walrus, and it was observed that the creatures used their long tusks for the same purposes to which the ice-hooks and anchors were applied. Thus a walrus, when in the water, could, with its tusks, anchor itself to a floating piece of ice, whilst the projections were simply invaluable in helping the animal climb about on the smooth surface.

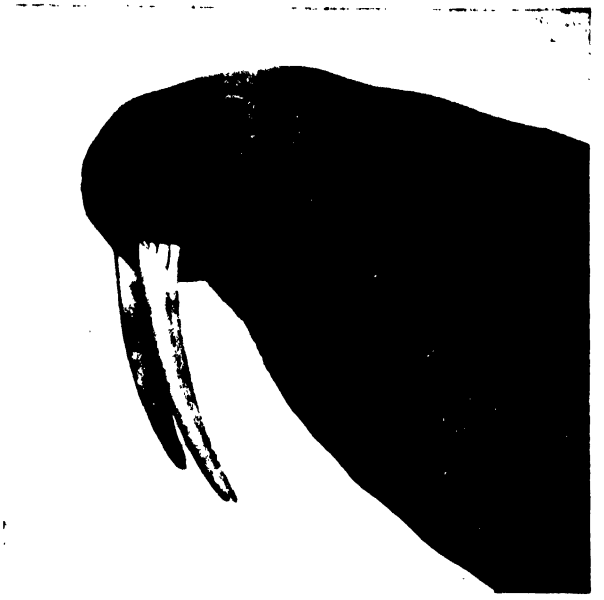


Photo H. S. Berridge, F.Z.S.

Natural Ice-hooks

The ice-anchor, so much in evidence on Arctic expeditions, was originally invented by the walrus

The trap-door is certainly a clever device, whether it is simply applied to the coal-cellar or the stage. One essential point is that it should fit exactly, so that there are no projections of any kind. This is not a very easy matter to arrange, and yet one of the cleverest trap-doors in the world is made by a spider. These creatures make their nests in the form of upright tubes in the ground. Over the opening is a most perfect little hinged door. When closed, this fits so well that the nest is completely guarded; to add to the security the spider often adorns the upper surface of the door with mosses and lichens similar to those which are growing around. In ordinary times the door is left open, but on the approach of any enemy the occupant of the nest pulls down the flap with great promptitude, literally shutting the door in the face of the unwanted visitor.

Photo: H. S. Berridge, F.Z.S.

The Cleverest Trap-Door in the World

The cleverest mechanic has never yet succeeded in making a trap-door so beautifully as the humble trap-door spider

The cottages of the countryside look

quaint enough, with their thatched roofs; this method of covering in a dwelling-place seems old, but it is not really ancient, neither is it an original plan. The South African Weaver-bird, long before our civilisation started, was carrying out an efficient scheme of thatching. It is the habit of this bird to live in great communities. That is, although each pair builds a separate nest, it unites with its fellows in the construction of a great protecting roof. This is formed of long grasses, placed in much the same way as that adopted by the thatcher. It is said that, on occasion, as many as two or three hundred nests have been found under one roof. Now and again the weaver-birds are too ambitious in their scheme, and make so large a roof that the branches are unable to support the weight, and the whole affair comes tumbling to the ground.

The railway tunnel would seem to be an essentially human affair, yet the idea is not original, as far as man is concerned. It seems strange to think that the modern plan of tunnel making is really based on the operations of the ship-worm. Yet it was after studying the methods of this creature that Brunel was able to push a tunnel through the loose soils which form the bed of the Thames. The plan of the ship-worm may be briefly described. The creature feeds upon the wood, but it does more than merely bore its way through the substance. As the burrow proceeds, the tunnel is lined by the ship-worm with a hard, shelly matter. Now our tunnels and tubes are made on this plan. A shield is forced through the soil, this being shovelled away through doors in the rear of the contrivance. As the tunnel progresses, the walls are at once lined with

Photo. H. Easton

The Original Model for the Modern Railway Tunnel

It was after studying the shell-lined burrows of the ship-worm (shown here about natural size) that Brunel was able to tunnel beneath the Thames

brick or stone, following the same plan as that so long carried out by the ship-worm.

One of the great needs of the angler is the constant renewal of his bait. In the remarkable Angler-fish (see p. 267) Nature has perfected a singular plan of fishing, in which the bait need never be replaced. The angler-fish is a strange-looking object, both as regards structure and coloration, and has an enormous mouth. On the top of the head of this fish there are arranged a number of bones, and on the ends of these are certain appendages. Now these appendages are very much like fish, and the resemblance is further strengthened on account of the fact that the angler-fish keeps wagging the bones about. The trick works so well that fish of all sorts are constantly darting at the tempting bait, with the result that they are inevitably snapped up by the great jaws. It is said that, but for this clever arrangement, it is hardly likely that the angler-fish would be able to keep itself alive at all, seeing that it is a sluggish swimmer, and never seems to have sufficient energy to hunt for its food.

The various tools and appliances which mankind has adopted are, after all, copies of devices to be found in the natural world. In the case of the Woodpecker's beak we have a wonderful combination of a hammer and a sort of pickaxe. The bird, of course, lives upon small insects and grubs which are to be found in the crevices of tree trunks. It is said to be the custom of the woodpecker to hammer away with its beak, thereby alarming the insects. In their hurried flight many of the little creatures are captured. Where the insects retreat to some out-of-the-way

Photo S. L. Bastin

The First Hooks in the World

Long before man emerged sufficiently from savagery to fashion a hook for himself the plant world was well provided with them. The seed-vessel of the South African Grapple-plant, shown above, has them several inches in length

corner, or, in the case of many grubs, the woodpecker employs its beak on the lines of a pickaxe, tearing open the bark so as to get at its prey.

The Earliest Pincers

One of the most useful of tools is a pair of pincers, yet as far as man is concerned the handy implement is not in the least original. Untold ages ago Nature equipped the crabs and the lobsters with particularly efficient pincers. The claws of these animals are, of course, used as weapons of defence, but they are even more freely employed in tearing to pieces the creature's food.

It is probable that the comb as a toilet adjunct is one of the oldest appliances. Yet the plan of the comb is a well-established device in the natural world. One of the most remarkable instances is that of the Toucan's beak. The bird is, of course, a native of tropical America, and when kept in captivity has been seen to be very particular about its plumage. The Toucan dresses its feathers with its beak, the saw-like notches of which act the part of a comb. It is a curious spectacle to see the bird carefully combing all its feathers out; the business does not cease until the whole of the plumage has been put in order.

In the vegetable kingdom also there are a number of very striking cases which, when compared with certain human devices, prove to us that there is only one really proper way of doing a thing.

Nothing is quite so much exposed to the force of the elements as the lighthouse on an isolated rock. The first attempts to erect a warning beacon on such a place were made in connection with the famous Eddystone. Here two or three structures were swept away, not so much by the violence of the waves as by the tremendous force of the wind. Then Smeaton came along, and he saw that to be successful the building must be on an entirely new plan. Taking as his design the plan of an oak tree, he copied the graceful curves of the trunk in his lighthouse, spreading out the base to the foundations, which played the part of roots. The method was wholly satisfactory, and since this plan was adopted there have been no disasters to lighthouses. To-day lighthouses all over the world are modelled on the lines of the oak tree.

One of the most valuable principles in architecture is evidenced in the buttress. Than this there is no more satisfactory method of supporting a wall which, owing to its height, or the fact that it is old, seems to be in danger of falling down. The principle of the buttress was known to the builders of our ancient cathedrals, yet the device is far older. In the forests of the warmer parts of Australia there is a remarkable tree which has the power of throwing out buttresses to an extraordinary extent. The tree is a kind of fig, and it grows to an immense height, quite often shooting up to 100 feet, or even more. The buttresses of this fig-tree, which in all ways is one of the giants of the plant world, are thrown out so far that it is often possible for men and horses to find shelter between them. Without a doubt these outgrowths from the main trunk act as a real support to the tree, which, on account of its great height, would offer an immense amount of resistance to the wind.

Wonderful Wedges

For the purpose of forcing a way through an object there is certainly nothing so effective as the wedge. From time immemorial the wedge has been employed by mankind, but the principle is far older than any human invention. There is nothing more common in all the world than grass, and perhaps on this account few people stop to think how wonderful is the growth of the delicate blades. Even in the hardest and stoniest grounds these tender shoots force their way uninjured through the soil. This they are able to

Photo: Kerry &

How Early Architects May Have Learned the Use of the Buttress

Just as the oak tree provided a model for Smeaton's lighthouse, certain forest giants demonstrate the utility of the buttress to maintain them in an erect position. Were it not for these natural buttresses the Australian fig tree here shown could never withstand the wind strain on its great height

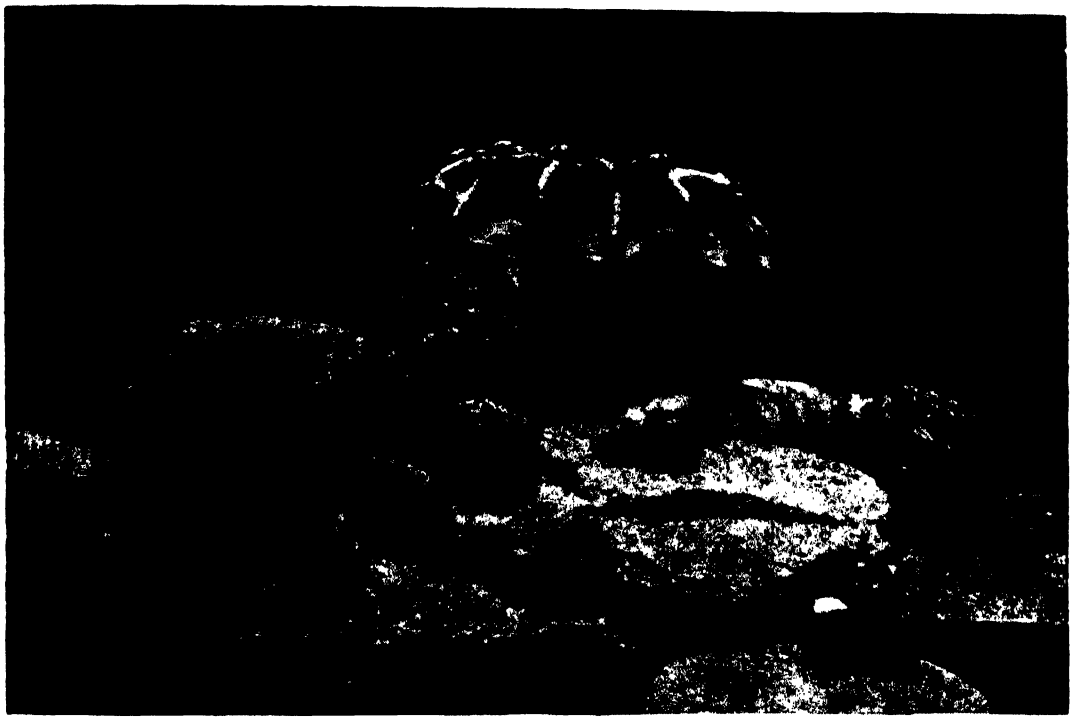
do simply because they grow on the lines of a wedge. Every blade, one observes, terminates in a point of the finest description, and it is this which first opens up a passage through the soil.

There cannot be much doubt that the idea of the suspension bridge was first of all suggested to mankind by the wonderful lianas of the tropical forests of South America. These creepers are quite the most wonderful features of the vast wooded tracts which the white man has penetrated to such a small extent. The lianas are the most energetic of all climbing plants, sending out great shoots from one tree to another, and in the course of their ramblings travelling hundreds of feet. Now and again the creepers sway right across some ravine, and in this way a natural suspension bridge is formed. These bridges are not only largely used by the animals of the forest, but the natives of the district also pass freely along the hanging way.

Long before mankind was sufficiently intelligent to invent even the simplest kind of hook, Nature had found out the value of this appliance. There is no more striking instance than that of the seed-vessel of the South African grapple-plant. This is several inches in length and is covered with a large number of curved hooks which catch hold of any object that may come against them. The plant which is responsible for these formidable fruits is of a trailing nature, and woe-betide the traveller who should brush against the long stems, covered with the hooked seed-vessels. The hooks catch hold of the clothing, and will even tear and rend the flesh. Animals very often suffer a great deal in this way from the grapple-plant, although, without knowing it, they confer a benefit upon the vegetable by helping to distribute its seeds.

From very early times the ingenuity of mankind has been taxed to devise means whereby animals may be captured. One of the oldest plans is that of the baited trap, and it is interesting to find that both in natural and in human invention the lines followed are very similar. Quite one of the most remarkable plants in the world is the Venus Fly Trap of Carolina, illustrated on pages 12 and 13, which has leaves divided into two parts, joined together by a hinge-like apparatus. The insects are attracted to the leaf by a sweet honey, only to be trapped and die when the hinged leaf closes on them. Now the whole scheme is almost exactly on the lines of the gin-traps with which man captures rats and rabbits. In this case we have the bait which attracts the animal; whilst attempting to feast on the morsel the spring of the trap is released, so that the cruel teeth close together over the unfortunate victim. The means by which the capture is accomplished is really identical.

A plan followed by gardeners who feel that the birds are taking a heavy toll of the crops is somewhat on the following lines. A few sticks are stuck in a pot of soil which has been sprinkled with crumbs. A number of strands of cotton are wound between the sticks, and on to these bird-lime is smeared. The birds, in their efforts to reach the crumbs, become entangled in the sticky cotton, and are quite unable to get away. Now there are quite a number of plants which have adopted what one may call the bird-lime plan of capturing prey. The most singular of these is the Sundew. The whole of the foliage of this strange plant is covered with reddish hairs, which from their tips exude a sticky substance. This sticky stuff is perhaps of a pleasant taste; at any rate, it seems to attract large numbers of flies. Very soon the horrible sticky substance completely envelops their legs and wings, so that they simply struggle until they die. The plant, by means of special digestive juices, is able to absorb the nutriment from their bodies.



The Mother Cactus

Produces a large number of offshoots, which are continually breaking away from the parent and may be blown to a considerable distance before settling down

Tourists of the Plant World

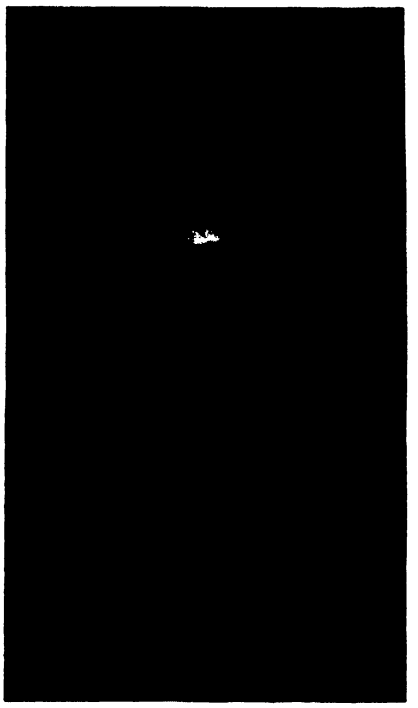
Ferns, Lilies and Cacti which Travel
—The First of Flying Machines

IN a general sense we must think of the plant as chained to one spot. There are, however, some quite remarkable species which are noted for their touring propensities. One of the most singular of these is certainly the jumping fern of New Zealand. This plant produces narrow leaves of immense length, in such a way that sooner or later these fall over so that their tips touch the ground. When this happens a very remarkable thing takes place. Quite soon a bud is produced at the extremity of the leaf, and this rapidly develops into a baby fern plant. Ultimately, the new fern grows into a large size, and in turn starts to jump with its leaves to fresh places.

Other kinds of touring plants send out long trailing stems to search for fresh rooting places. A little Alpine saxifrage is curious in this respect, for the plant will traverse over many feet of barren rock to reach a suitable position. Directly the shoot touches the soil, a new plant is formed, and as this grows up, the connection between it and the parent is severed. A kind of lily has an even more singular way of travelling about. Here, after the plant has flowered, buds arise on the stems which bore the blossoms. Eventually the stems rot away from the base and fall over. Being rather long they reach a good way across the soil, carrying out the baby plants

to root in fresh positions. This plant if left alone would rapidly cover many yards with its offspring, and this without setting a single seed.

A strange group of plants are those which actually break themselves in pieces in order to pursue their journeys abroad. A plant belonging to the Houseleek order (*Sempervivum soboliferum*) is remarkable in this respect. The species naturally finds its home in the crevices of rocks, and at a certain stage in its development numerous little ball-like offshoots are produced. In the early days these are kept at home by the stems by means of which they are attached to the parent plant. Eventually these attachments shrivel up and the offshoots go rolling away over the rocks often much helped in their journey by the wind. A considerable distance may be traversed before a little ball finds a resting-place in some niche. Before many weeks are past the offshoot will have secured a roothold. Very much the same kind of thing is to be seen in a species of cactus, which has been well called the Mother Cactus (*Mammillaria*). In this case the plant bears a large number of baby plants all round itself. When these reach a certain size they become detached and, rolling away down the rocks, settle finally in some crevice. As soon as the journey is at an end, the little plant sends out roots, and starts to grow on its own account.



The Parachute of a Dandelion Seed or "Clock"

Many plants provide their seeds with an apparatus which forms a singularly effective flying machine. Some of these are among the most beautiful and ingenious contrivances in the plant world.

By far the commonest method of ensuring a wide distribution of a seed is that in which the object is attached to some light, feathery substance which prevents a speedy falling. Of this there is no better instance than the common dandelion, which at seed time produces the handsome "clock" so prized by the children. Here each seed is attached to a feathery process which plays the part of a parachute. On a dry day, when the dandelion heads are parting with their fruits, we may see how well the scheme works. Each puff of wind releases a few of the seeds, and these, unlike the ordinary parachute with a load, are so light that they rise upwards on the air currents.

Curiously enough, the fruits seem to travel farther when the breezes are light, and a very rough wind blows them back to earth, where they may catch in the grass or become damaged. Thus, like the airman, the dandelion seed stands the best chance of a safe journey when the weather is not too boisterous. A very similar arrangement is to be seen in the case of the goat's-beard fruit and that of the coltsfoot, which, by reason of its flying device, secures a very wide distribution. That the seeds of these two plants—both of them troublesome weeds—are often carried to a considerable distance, there is little reason to doubt.

In making any flying machine the designer must naturally bear in mind the

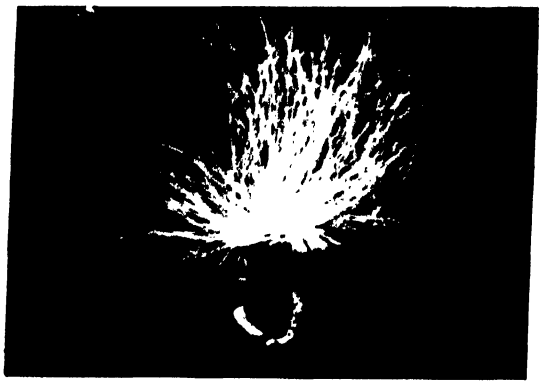
The Jumping Fern

This fern, which is a native of New Zealand, has the remarkable habit of producing small plants on the ends of its long leaves. By this means the plants will often travel a considerable distance

A Touring Lily

This plant, which is a kind of lily, has a novel way of touring about. When the plant has flowered, the stems die down at the base and fall over. Meanwhile fresh little plants are budded off from the upper part of the stem

importance of keeping down the weight. This point has not been overlooked in the development of some of the aerial fruits. One of the most curious of these is that of the willow herb, a common plant in moist places. Now, the strange thing about the willow herb is that we shall always find it wherever there is a damp patch, even though this piece of ground is surrounded by miles of dry country. We shall find a reason for this if we examine one of the flying contrivances with which the seeds of the plant are provided. After flowering, the willow herb develops long pod-like processes. During damp and stormy weather these pods remain tightly closed. On a day when the air is dry and the breezes are light, the sides of the case split open and reveal a prodigious number of perfect flying machines. The seed itself weighs a mere trifle, whilst to this is attached a beautiful arrangement of feathery hairs. The whole thing is so well adapted for an aerial voyage that it mounts rapidly upward on the faintest puff of air. It should be here explained that by experiment it has been shown that the air currents tend to move upward. So light are some of these flying fruits that they often rise to an immense height. It is not an uncommon thing for them to be found on mountains thousands of feet above sea-level.



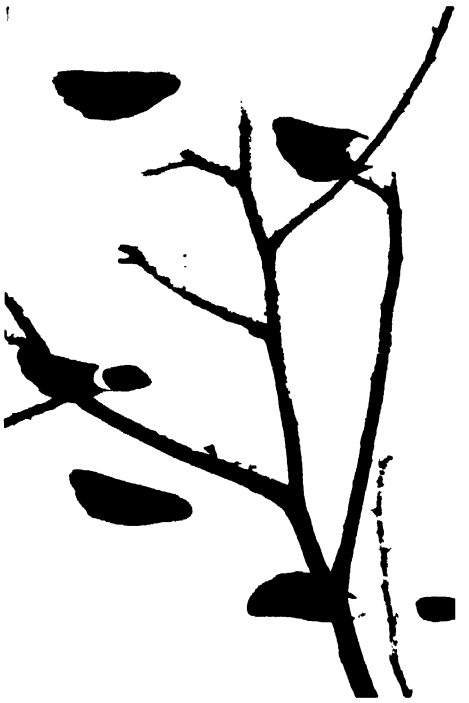
The seed of a South African plant (*Stapelia*) is supported in the air by a beautiful arrangement of silky hairs, and is often wafted a considerable distance

When the fruits of the Coltsfoot are ripe the smallest puff of air disperses the seed over a wide area

The head of a seeding Dandelion. Observe the enlarged view of one of the parachutes on page 378

Of course, many foreign seeds have remarkable flying appendages. That of the South African *Stapelia* has a vast mass of fluffy hairs which will support it on quite a long aerial voyage. In the case of the cotton plant mankind has turned to good account the long hairs by which the seed flies.

In a large number of cases the conveyance of the seeds to a distant point is accomplished by the adoption of the screw-propeller principle. An excellent example of this is to be seen in the fruits of the sycamore. Here the actual seed is large and heavy, but it is attached to a wing-like expansion. When the fruit falls from the tree the wing revolves with great rapidity, very much on the lines of a propeller blade. This has the effect of controlling the rate of fall, so that the whole contrivance is carried to some distance before the seed is actually brought to earth.



When the winged fruits of a Californian Pine (*P. Coulteri*) catch in any obstruction, or even knock smartly against an object, the seed is immediately dropped to the ground

The seed of the Sycamore is provided with a long wing These wings revolve quickly when the heavy seed is falling, and prevent a rapid descent. Meanwhile the fruit is carried a considerable distance

The Willow Herb produces an enormous number of flying fruits. These often sail away in masses and are carried for a great distance over the countryside

An enlarged view showing how the flying fruits of the Willow Herb are produced. The seed, which weighs a mere trifle, has a beautiful arrangement of feathery hairs attached to it

The Age Of The Earth

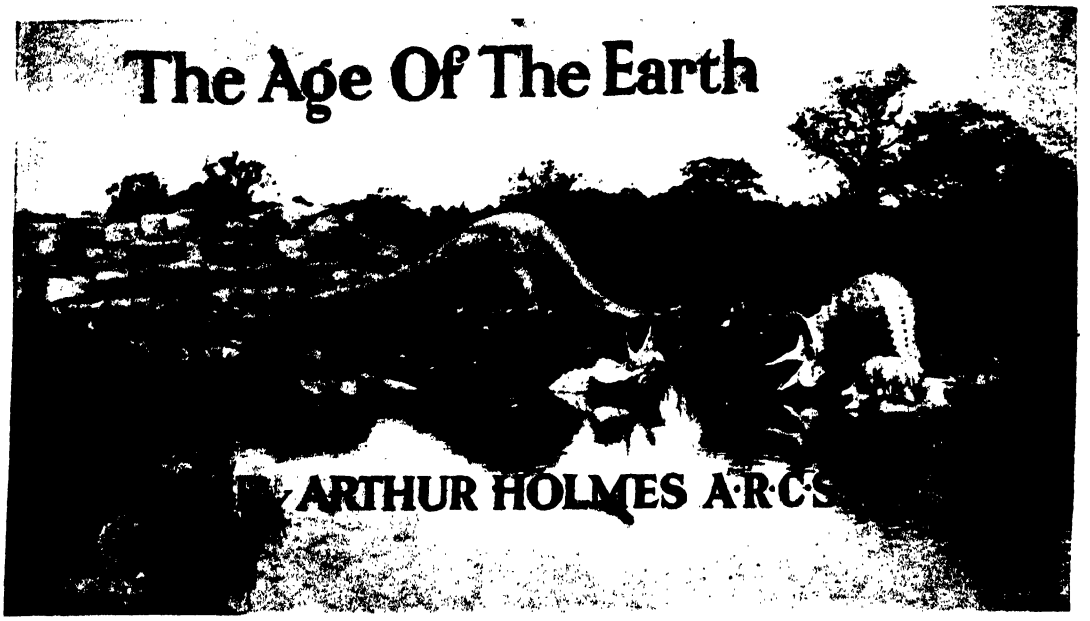


Photo: T. Kennes

Reconstruction of Prehistoric Animals at Herr Hagenbeck's Zoo at Hamburg

The Geological Hour-glass—How it Records an Age of at least 1,600 million Years—Radioactive Timekeepers

IN contemplating a magnificent cathedral or a venerable pile of ruins, almost the first question which occurs to us has reference to its age. And for the same reason scientific men, surveying their planetary habitation, and feeling an irresistible craving to know something of its antiquity, have, in the hope of satisfying their daring curiosity, developed various methods of attacking this perplexing question. The earth, however, guards her delicate secret with proverbial anxiety, and, we might almost say, has hitherto taken special pains deliberately to mislead her shameless interrogators.

The geologist, overwhelmingly impressed, on the one hand with vast thicknesses of rock debris piled up mile after mile in the great mountain ranges, and on the other by the extreme slowness with which similar formations are accumulated at the present day, has before him a most convincing object-lesson of the enormous duration of time which has elapsed since land and sea first began their eternal struggle for supremacy. The waters, taking full advantage of their mobility, sail over the continents in fleecy, cloud-winged aeroplanes, and, descending as rain, help forward the destruction of the land by breaking up the rocks, carrying them down to the river valleys and hurrying back to the oceans with their load of silt and gravel.

The continents are compensated for this continuous wearing away by the slow rhythm of pulsating earth movements. The sea-bottom is depressed beneath the gathering weight of sediment, and, deprived of the same material, the lands rise upward like the pan of a gigantic balance. Nor can the sea retain indefinitely the broad ribbons of sand and mud which everywhere fringe the land, for a time comes at last when the strain impressed upon the underlying rocks is no longer endurable. Under the intense forces thus aroused the sediments are uplifted, fold upon fold, and crumpled together in mighty ranges such as the Alps and Himalayas. But great as those natural monuments of the earth's

ceaseless activity may be, they are but the relics which have resisted for a time the devouring agencies of glacier and torrent. The colossal hour-glass of land-destruction and land-formation runs unceasingly, and in so far as its obscured records can be deciphered, it provides the geologist with a scale of cosmic time such as he requires.

In the accompanying diagram, the great formations which build up the continents

Drawn by John Gaud

Sedimentary Formations of the Earth's Crust

The maximum thickness of each formation is given in feet. It will be seen that their total thickness exceeds the enormous total of sixty miles

are shown in order, and it will be seen that their maximum thickness exceeds the enormous total of sixty miles. How long is it since the first of these rocky pages of earth-history was written? If, guided by the formation of loose sediments at the present day, we guess that one foot of firmly compressed rock would be formed in 1,000 years, or say one mile in 5,000,000 years, then the length of time represented by the accumulated sands of the geological hour-glass is evidently more than 800 million years.

The uncertainties in this method are, however, too numerous to inspire confidence in the result, for, while some geologists would protest that present-day deposition may be much more rapid than one foot in 1,000 years, we have no direct proof that, throughout the remote past represented by the sands of time, the hour-glass has been running at the same unvarying rate. As we shall see presently, it is not improbable that the present day is characterised by more than average activity, and that, far from having slowed down in the course of the ages, or even from having proceeded with a monotonous regularity, the earth's energies have pulsated in cycles of alternate intensity and stagnation. The conditions of the geological epoch in which we are living cannot, then, be accepted as representing average conditions. Amid all the confusing details of earth movement—self-confessed by devastating earthquakes, landslips, and volcanic eruptions—some great cycle is running its course, and, until we can judge what place the present takes in this broader scheme of terrestrial activity, it is impossible to deduce a convincing estimate of the earth's age from geological statistics alone.

It should be said, however, that, until quite recently, it was almost an article of

ONE OF OUR EARLY ANCESTORS, A PRIMITIVE

(Drawing by Kupka, of "L'Illustration," fro

This reconstruction of one of our primitive ancestors is based upon a careful study of his remains found by scientifi indications buried in the ground under the dust of ages, so the geologist can disentangl

CAVE-DWELLER OF MANY THOUSANDS OF YEARS AGO

mes found in the Department of Corrèze, France)

elvers at Chapelle-aux-Saints. Just as it is possible to conjure back the form and habits of remote man from he story of earth's beginnings by a study of the deep-buried strata which forms its crust

geological faith to believe that the age of the earth was about 100 million years. This belief was supported by another "hour-glass" method, in which attention was directed not to the sands of time, but to the salt of the earth. Ever since the inauguration of land and sea, the oceans have been steadily enriched in sodium, most of which is present as common salt. Apparently, only two factors are necessary to determine the age of the oceans. First, the total amount of sodium accumulated; second, the amount added each year. These quantities are tolerably well known from analyses of river and ocean waters, and one draws the simple conclusion that, at the rate of 130 million tons every year, an accumulation of 13,000 million million tons must have required 100 million years.

The Age of the Oceans

Unfortunately for our peace of mind the problem is much more complex than this, for part of the sodium is used again and again, and thus, being capital in circulation, it ought not to be reckoned as income. Fine particles of salty spray from the foaming crests of a storm-tossed sea are often blown inland, and underground waters flowing through the deep-seated channels of the rocks are responsible for an even more important transfer of salt from sea to land. Taking this fully into consideration, the age of the oceans, like that of the oldest sediments, works out at about 300 million years. As before, however, we are led to suspect that the oceans have not always been fed with so much salt as at present, and, therefore, that such a figure can only be regarded as a minimum value, which is undoubtedly too low.

Living as we do in an era of special activity, the earth has succeeded so well in maintaining a false appearance of youthfulness, that, until a decade ago, there was a long and bitter controversy between the physicists and the geologists as to the precise degree of youthfulness which she simulated. The physicists, with Kelvin as their leader, gallantly denied that she could be older than 40,000,000 years, basing their opinions on the view that the earth, born in space as a molten globe, must within that period have solidified and cooled to her present state.

Among the geologists, however, there was a prevalent expectation that some flaw would be found in this argument, which, supported as it was by the difficulty of accounting for the sun's long-continued output of life-giving rays, seemed to be quite irrefutable. Then, in 1903, as if to realise their optimistic anticipation, came the discovery by M. Curie of an undreamt-of source of heat in radium and its radioactive associates. In 1906, Professor Strutt showed that radium is widespread in the rocks of the earth's crust, and that, because of the heat thus being continuously generated, it became necessary to face a more embarrassing question than ever, for the richness in radium suggested that, far from cooling down, the earth must have been gradually becoming hotter. How this difficulty is dispelled, though a fascinating topic, cannot be followed up here.

It will now be obvious that these epoch-making discoveries resulted in the complete rout of the physicists, for not only is it inherently improbable that the earth was ever a molten globe, but more significant still is the grim possibility that the earth can supply more heat than she is able to lose. Thus the controversy was settled with all the honours in favour of the geologists, who hitherto had been mistakenly accused of drawing much too extravagantly upon the bank of time.

The Discovery of Radium

And now we enter upon the most interesting part of the story. Not only did the discovery of radium destroy the foundations of the cooling argument, but it led directly to the elaboration of the most elegant and refined method which has yet been devised. Every radioactive mineral can be regarded as a chronometer, registering its

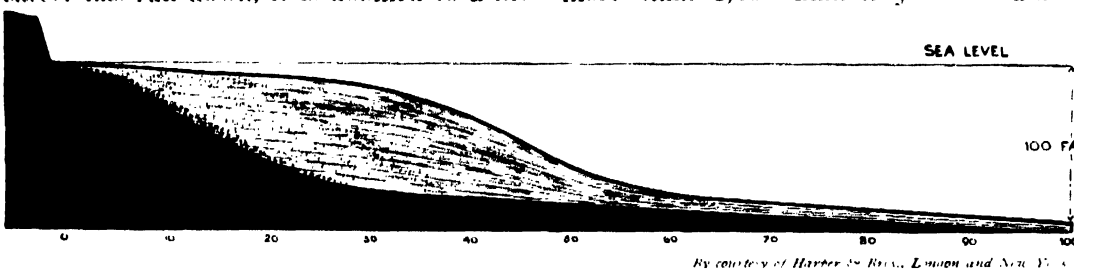
Drawn by John Gault

The Colossal Hour-glass of Land Destruction and Land Formation

This hour-glass runs unceasingly, wearing down the continents and spreading around their shores a broad ribbon of sand and mud. Observe the section through this ribbon of sediments at right of picture, which is shown again on page 388

own age with exquisite accuracy, and it is now known that the once poverty-stricken geologists need no longer restrain their eager appetite for time. Indeed, so enormous are the periods which have been revealed, that, to-day, they are confronted with a superabundance so embarrassing that it can no longer be comfortably digested.

To understand the method of reading our natural chronometers, it is necessary to know that the mysterious element, radium, is constantly being born, and is just as constantly dying. Uranium, the heaviest known element, is its parent, and when at last the mechanism of its explosive career has run down, it is doomed to a life of stagnation in the form of lead. We say, an "explosive" career, because, at eight distinct stages, particles of the gas helium are ejected with inconceivably high velocities. Now, both lead and helium are stable and permanent elements, and as their weighty parent disintegrates, they slowly accumulate at its expense. In that fact lies the foundation of yet another hour-glass method of measuring time.



By courtesy of Harper & Bros., London and New York

Section Illustrating the Formation of Sediments on the Continental Shelf while the Latter is Being Slowly Depressed

The transformation is a very leisurely process, so slow that in 5,400 million years, only one half of the original uranium has broken up into helium and lead. It will, therefore, not be surprising to learn that a million million grams of uranium only produce 19 grams of helium and 120 grams of lead in the course of a year. The importance of uranium-bearing minerals will now be seen. They may be regarded as natural storehouses in which helium and lead are produced unceasingly year after year. The older the mineral, the greater will be the quantities of these elements which it has accumulated since its birth.

As an example, let us take a mineral from some of the oldest rocks in the world. Certain specimens of thorianite from Ceylon now contain about 9 per cent. of uranium, and 2 per cent. of lead. When the mineral first crystallised out, there was 11 per cent. of uranium and no lead, so that, on the average, ten parts of uranium have produced two parts of lead since then. How long would this take if, as we know, a million million parts of uranium produced 120 parts of lead each year? Evidently more than 1,600 million years would be necessary, and we may, therefore, say with confidence that the earth is at least somewhat older than this.

As a criterion of age, helium is much less satisfactory than lead, because helium is an elusive gas which readily escapes from the minerals in which it has been imprisoned as soon as they are taken from the rocks to be analysed. It therefore gives us ages which are far too small; never, in fact, being more than half the real value. A few of the older geological periods are given below, with their corresponding ages, as determined by the accumulation of lead in the radioactive minerals which are known to belong to these periods:

	Million Years
Carboniferous	340
Devonian	370
Ordivician	430
Algonkian	1,000
Archean	1,600

The Age of the Earth

As yet, the records which have been deciphered are very meagre, but the method is brimful of promise, and the time will come when we can fix definite dates to all the great events of geological history, and calculate the antiquity of all the strange animals which have peopled our planet since life first began.

Radioactive minerals are, for the geologist, clocks wound up at the time of their formation, and, as the earth's historian, it is invaluable to him to be able to read these time-keepers correctly. The presence of radioactive elements in minerals is sometimes revealed in a most beautiful way. In mica, and tourmaline, and a few other minerals, small circular spots may sometimes be seen when very

Reconstructed by J. Sargent

A Beast of 300 Million Years Ago

Though the above period sounds a long time ago, our world was already at least 1,300 million years of age when the great fin-backed lizard (*Naosaurus claviger*) roamed the earth

thin sections of the rock are examined under the microscope. These patches, which are often strongly coloured, are called "pleochroic" halves, because their colour varies according to the direction of vibration of the light waves which pass through them and render them visible. Until 1907 their origin and even their nature was entirely unknown. In that year it was shown that they are due to the ejection of helium atoms from exceedingly minute crystals which occupy their centre, and which are rich in uranium. Altogether eight different sets of helium atoms are emitted, and for each set there is a definite distance to which it can penetrate. Thus eight tiny spherical shells, faint in youth, but intensely coloured in their later phases, gradually accumulate around the radioactive inclusion. So slowly do the haloes form that, in some cases, a week or more may elaspe between the expulsion of successive helium atoms. Last year it was found possible to estimate the age of certain Devonian granites, by comparing the colours of the haloes they contained with those of haloes artificially produced in the same mineral. The results obtained were somewhat in excess of the 370 million years cited above, and, therefore, constitute a remarkable corroboration of the immense periods which the radioactive timekeepers disclose.

In conclusion, we now know that the earth is at least 1,600 million years old. The sedimentary rocks, which began with the Algonkian formations, suggest a period of only 300 million years—whereas the true period is about 1,000 million years. This extraordinary discrepancy points to two possibilities. In so far as the geological record is incomplete, there are vast periods of time entirely unrepresented by sedimentary rocks, and, in so far as we are now living in an epoch of rapid deposition of sediment, we have under-estimated the time-value of that part of the record which still remains to us. It is probably along these lines that a reconciliation will ultimately be established between the two rival methods of attacking a subject which has provided infinite controversy.

Photo: Putnam & Valentine, Los Angeles

Harvesting Salt from Deposits in the Californian Desert

If the whole ocean evaporated, as here an inland sea has done, the salt would cover its bed as a deposit averaging over 160 feet in thickness. In calculating the age of the earth the amount of salt in the sea is a valuable guide

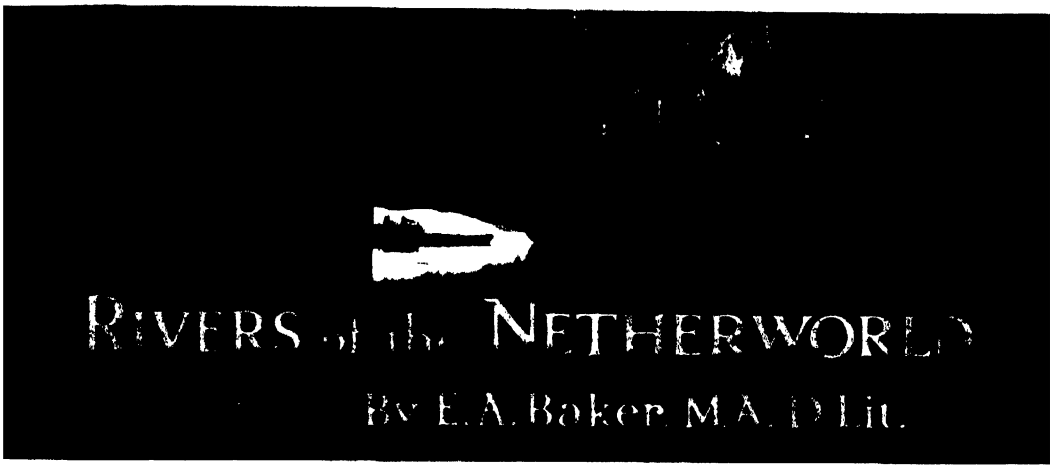


Photo: E. A. Mart.

Underground Lake in the Cave of Han-sur-Lesse, Belgium

Mysterious and Unfathomable Water Systems on which the Sun Never Shines Gorges, Rapids and Waterfalls beneath Earth's Crust

EXCEPT sea caves and pot-holes that are produced by fissuring, all caves are the work of underground streams. The chief business of speläeology, the modern science of caves, is the exploration of these mysterious rivers, and of the channels which they have deserted or which they now use only in flood time. A river, a number of small streams, or a lake, enters the ground by a sink-hole or swallet, or by one of the huge open gulfs already described, and after a journey of some miles reappears, swollen by tributaries, at a much lower level. Wherever limestone is the principal rock, underground streams abound. This rock, which is composed of carbonate of lime, is easily acted upon by the acids dissolved in running water. Corroded by this chemical agency, it is also worn away by the mechanical action of streams, and, in spite of its hardness, yields an open passage to the water. Chalk, which is a soft limestone, is permeated with water-channels. Beneath the area governed by the London County Council lies a vast reservoir of pure water, and in the Mole, which disappears into its bed near Dorking, and comes to the surface again on the way to Leatherhead, we are provided with a familiar instance of a river running underground. In the harder mountain limestone the course of such a stream would consist largely of high and spacious caverns.

Hitherto, the most extensive series of underground passages in Britain has been supposed to be the Mitchelstown Caves in Ireland, which altogether run to about two miles. But last September the present writer and another speläeologist made a preliminary exploration of an underground river in county Clare, which, in all probability, exceeds this considerably. Clare and county Galway are a land of subterranean streams. Little water is seen on the surface, which is largely naked limestone; and it is possible that this river will be found to enter the sea by a submarine channel. Such is the case with the freakish river running through Gort. Rising in a lake, this disappears after a mile or so in the Devil's Punch Bowl, comes to light in various pot-holes and open caves, and, after other antics, flows quietly into Lough Coole. From this there is no outlet on the surface; but the water has been proved to proceed underground into Galway Bay, discharging below tide-level.

At Marble Arch, near Enniskillen, a mountain stream has carved a chain of enormous galleries and soaring vaults in a limestone hill that barred its path. Above the commencement of its darksome journey the river comes down a gorge, ending abruptly in a face of limestone, 130 feet sheer, against which it has been known to pile up its waters in flood-time right to the top. In the cave at the base of this cliff trunks of trees can be seen jammed high in the roof—a standing witness to the furious strength of the winter torrent. One can swim down-stream a short distance, and then the roof comes down to the water. The hill beyond is pierced in many places by pot-holes and wide cavities, where the superincumbent strata have been undermined and collapsed, and these give access to the river. But the finest stretches of this great water-cavern are reached from below. The first explorers made their way up in a boat, but a dry entrance has now been discovered, which involves, however, an awkward and intricate climb that few people would attempt. As nearly always happens with underground streams, the continuity of the water-cavern is broken at several points, where the streams flow under the rocks in a kind of inverted siphon. Thus, the channels through which Lough Mask, in Connaught, drains into Lough Corrib are quite impenetrable to man. I was once induced to don a life-belt and attempt to find a way upstream from where the river from Noon's Hole, already described, flows out at Ooboraghan; but similar difficulties soon drove me back.

Photo L. A. Martel

The Landing Place in the Vast Cave at Padirac, France

A squadron of boats is at hand to conduct the more adventurous along this wondrous river, whose cascades and difficult portages caused the original explorers a world of trouble

The behaviour of the Manifold, which

runs below the ground for some miles before emerging close to Dovedale, is well known to tourists in Derbyshire; but in the same district there are mysterious risings, fed by underground streams, about which we know absolutely nothing. A compact illustration of the vagaries of limestone streams, which anyone can see without difficulty, is the upper course of the Dale Beck, near Ingleton. From the arched mouth of Gatekirk Cave it comes into the daylight as a good-sized stream. At the expense of a scramble and a long crawl, one can make one's way into the cave itself, where the underground rapids, pools, and waterfalls are very impressive, and enable one to realise the deafening uproar caused by the concentration of echoes in a water-cavern. A few hundred yards lower the river quietly slips away into its bed, and nothing is visible beyond but the dry storm-course, except an odd pool or two fed by the hidden waters. But at Weathercote Cave there is a magnificent scene. From the cliff walling an open pot-hole the river suddenly leaps out of a black tunnel, falls 90 feet in a splendid cascade, and thunders on into another archway beneath our feet. And now for several miles the old river-bed is a dry pavement, with here and there a gash or pit, at the bottom of which the waters can be heard; until at God's Bridge the river comes welling out from under natural masonry, before plunging down the famous Ingleton Falls, in a gorge cut in the Silurian strata.

The Beck, which disappears in Gaping Ghyll, is the same stream that traverses the Ingleborough Cavern, and for twenty years persistent attempts have been made to trace the whole of its course. The limestone formation of the Pennine is responsible for the underground rivers of the Peak. Both Peak Cavern and the Speedwell are traversed by the same river, and the exploration of these caverns entailed a great deal of aquatic exercise. One of the most extensive in ground-plan is the Bagshawe Cavern, which is the work of a stream that now cuts across the head of the cavern and flows down a gallery not yet explored. I shall never forget the anxiety of a night some years ago, when two friends got lost in this cavern, and we, in the rescue party, feared all the time we were searching for their traces that the river might overflow into the Dungeon—a subterranean pot-hole connecting the upper and the lower series—and cut off our retreat. We saved our friends, and got out with no

Photo Hawkes and Partridge, Wells

The Second River Chamber, Wookey Hole Cavern

Photo J. A. Mavin.

An extraordinary Stalagmite on the Bed of the Underground River at Padirac

mishap; but on my next visit to the cave I found the Dungeon submerged beneath a swirling flood, and the long suite of passages in which we spent that exciting night completely drowned out.

During recent years parties have been cut off for twenty-four hours at a stretch by sudden floods in Gaping Ghyll and Helln Pot. But the most thrilling incident happened in 1910, when the present writer was one of an exploring party caught in the depths of the Eastwater Cavern, in Somerset, by a flood pouring in at the entrance 400 feet above our heads. Hours were spent in a difficult traverse from one branch of this savage and dangerous cave to a parallel branch, only to encounter another torrent where no human being could live; and it was only after preparations had been made for keeping alive on a starvation allowance for several days, that a temporary abatement in the flood enabled the party to rush the exit. This cave, which absorbs a small stream on the top of the Mendip Hills, is one of the feeders of Wookey Hole, where the river Axe flows out from mighty vaults and huge underground lakes, some of them inaccessible to man. Another feeder is Swildon's Hole, in which exploration has been stopped at a depth of 300 feet by an impassable 60-feet waterfall. In Eastwater we have gained a depth of 550 feet below the surface, the deepest yet reached in Britain.

The rapidity with which these underground waters rise to a height far beyond their ordinary volume is astounding. Some of the subterranean rivers of the Continent, on the other hand, are big enough under normal conditions to make exploration both toilsome and hazardous. Those which run through the caves of Han, in Belgium, and of Adelsberg, which has been mentioned as the longest in Europe, are, as a rule, placid enough for tourists to be taken through in boats without the least danger. Very different is the succession of subterranean gorges, rapids, and waterfalls, by which the Recca cuts its way through the great barrier of the Karst to

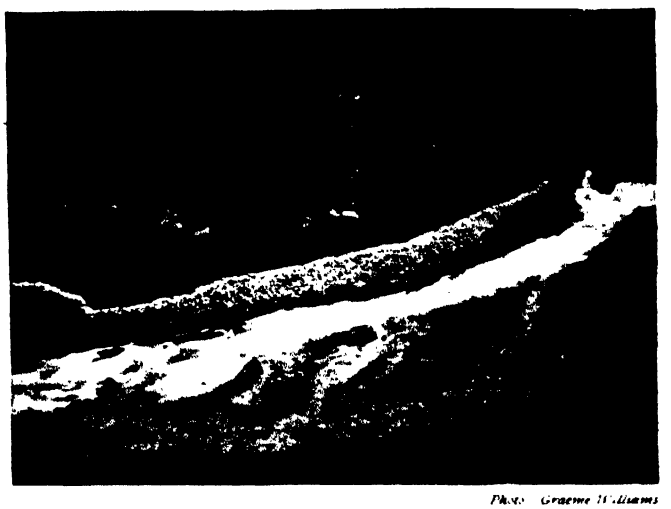
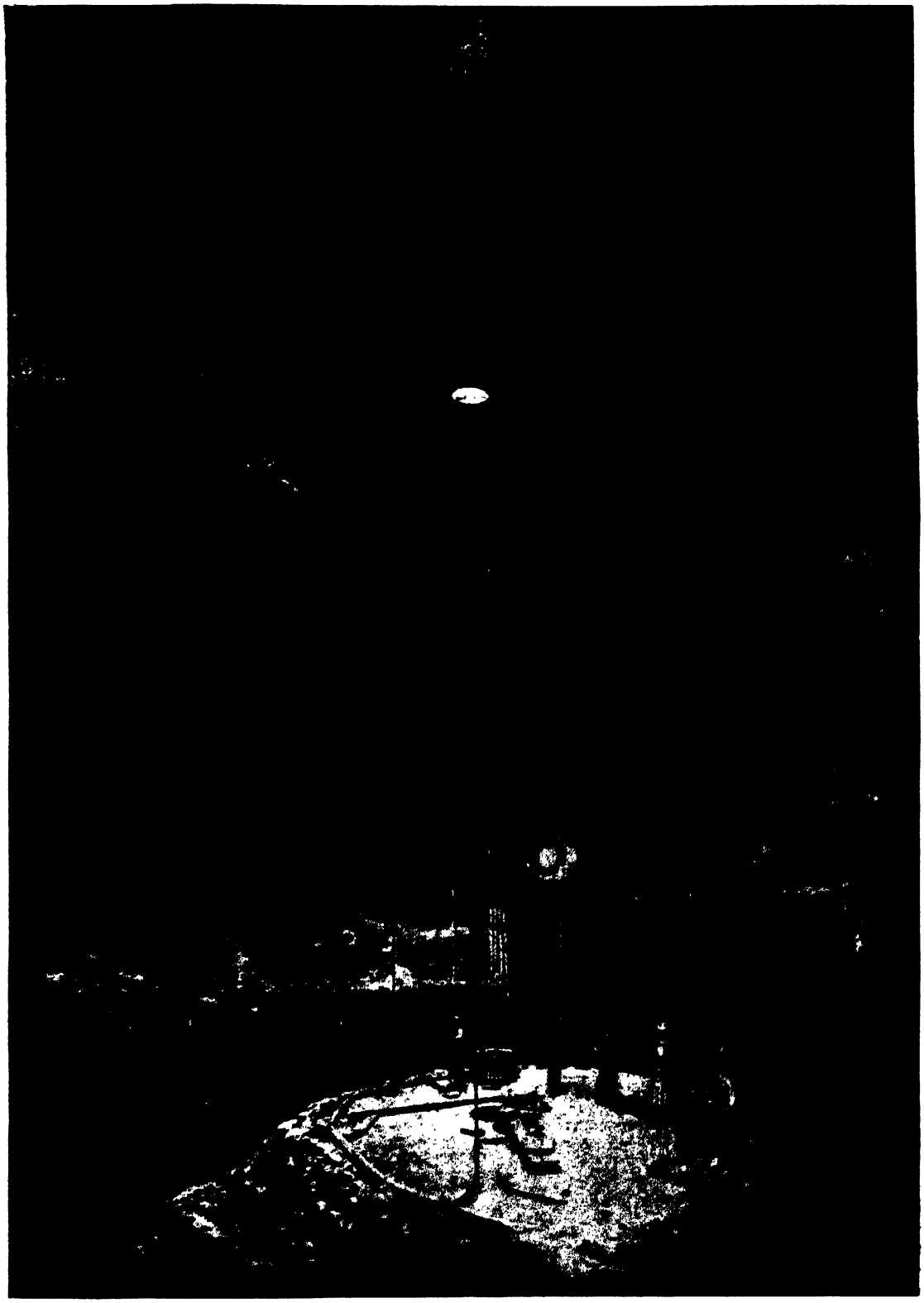


Photo Graeme Williams

An Impetuous Stream issues from the Ricklow Cave, near Monyash, Derbyshire



The Interior of the Cavern of Proumeyssac, in the Dordogne

This mighty cavern, 471 feet in extreme depth, and 180 feet long by 120 feet broad, has been cut out, it is believed, from the bottom to the top by the swirling action of an underground stream. The mound in the centre, nearly 400 feet in height, consists of debris washed down from walls and roof by the action of the hidden river when swollen by flood

the Adriatic. This is one of the most stupendous examples of river scenery on the face of the globe. Though but a portion of the total distance traversed is accessible (some 2,100 metres, ending in the Lake of Death), the exploration, begun in 1840, was not finished till 1893. Foaming down a series of falls, the Recca plunges into a cave, the roof of which is pierced with chasms, one of which gives access to the stream. The river reappears at the bottom of a profound cañon or doline, plunges again, and again reappears, before taking its final leap into the gloomy entrails of the Karst. Tracks have been engineered along the sides of these open cañons, and still more sensational galleries and bridges have been constructed in the subterranean gorges beyond, where the roof is at least 240 feet above the river, and mostly far beyond the range of vision.

The later course of the Recca is unknown. In truth, there are few caverns where it is possible to enter with the stream and come out at its exit. The only one known in the British Isles is at Boho, in Ireland, where a small river pierces a limestone barrier from side to side, creating an almost inextricable labyrinth of passages in the interior. A more celebrated example is the great cavern of Bramabiau, in the Cevennes. There, the Bonheur river is engulfed in an open tunnel, and, after traversing a complexity of cavities and fissures, flows out through a gallery navigable to small boats. The Tindoul de la Vayssière is noted less for its river than for its underground lakes. Here, as at Padirac, stairways have been erected to enable the public to visit the interior. The stream that runs through the Combettes, in the department of Lot, gave the original explorers serious trouble, from the impossibility of using boats.

Marvellous underground rivers are to be found in all parts of the world, found, but not always traced or even seen. What becomes of the many rivers that plunge into impenetrable holes? What becomes of the water from the Mediterranean that runs into the ground close to the shore, on one of the Ionian Isles, and in its downward course—inland—drives the watermills of Argostoli? This instance seems to focus in itself all the unfathomable mysteries of the waters under the earth.

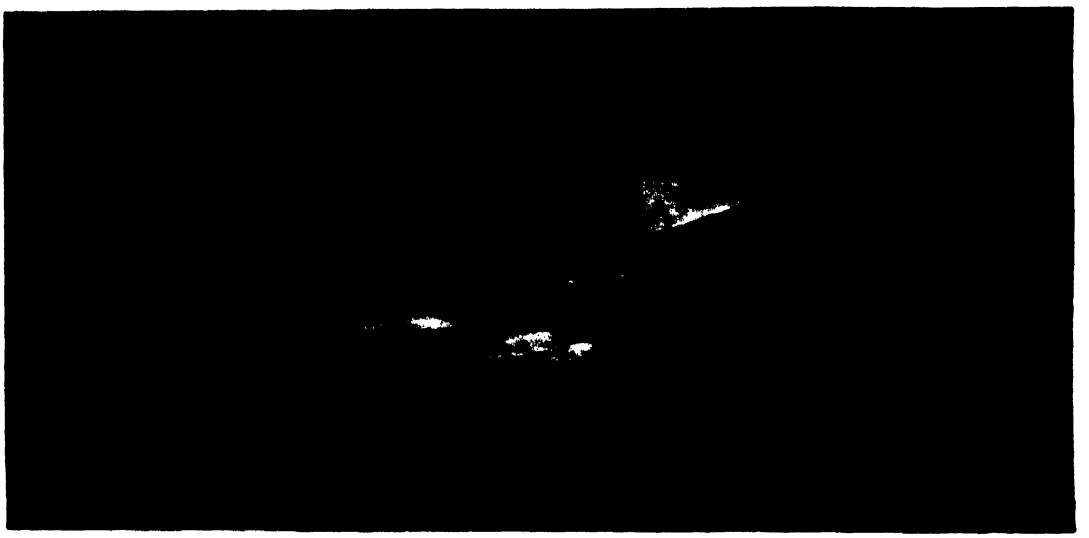


Photo: E. A. Baker

The Third Chamber at Wookey Hole

Observe the white head of a man, about the middle of the photo, sculptured by, and reflected in, the water with extraordinary fidelity

Trade Winds

The Road-makers of the Ocean Highways

By REGINALD C. FRY

THE average landsman is accustomed to look upon the wind as a poor sort of friend. Even in its absence he may blame it; when, for instance, he swelters beneath the glare of a fierce sun, Æolus often refuses to release the lightest of breezes. On the other hand, when the weather is penetratingly cold, and a westerly gale drives the rain through and through the stoutest of clothing, he roundly denounces the keeper of the winds as a tyrannising bully.

With our climatic conditions, we are so used to this idea of inconstancy on the part of the wind that we can hardly imagine a steady breeze that blows, season in and season out, all the year round, without ever changing its course, or that, so far from plaguing man, works night and day in his service.

Yet, such winds, both never-failing and constant as to speed and direction, blow regularly across the ocean in certain latitudes. Such kindly winds are helpful not only to the sailing ships which still sturdily plough the seas, but even to the mightiest of steamers, whose weather-wise skippers reckon to add some useful knots per hour to their going when the welcome and sought-for Trade Winds are encountered.

Never-failing and Constant

From the very earliest of times the Trade Winds of the North Atlantic were, on account of their helpful constancy, the great ocean road-makers followed by traders to the West Indies and Central America. It was thus that the name by which this ocean helpmate to man is known came into being. In the days of Columbus and his intrepid crew, the "Trades" were thought by them to be a visitation from God as a punishment for their bold daring in seeking a new land in the West. So persistently did they blow against them from the north-east that Columbus's men, when homeward bound, thought that the same winds which had helped them when going westward to America were sent to prevent them from ever reaching Spain and home again. The cause of the phenomenon is simply understood, however.

At either pole is a region of calms, estimated at from one to one and a half degrees in extent. Outside this is a district extending for many degrees, over which prevail winds running from all directions towards either pole. Beyond this (southward and northward of the Equator) are the calms of Cancer and Capricorn respectively. Further towards the Equator still are the belts of the north-east and south-east "Trades," separated by the zone of equatorial variables and rains. These facts are readily to be followed from the diagram on the following page.

Polar Calms

Bearing in mind the rotatory motion of the earth from west to east, it will be understood that a current of air coming from the North Pole, where the earth's motion is scarcely felt, towards the Equator, would —the farther south it travelled—find itself more and more affected by the rotatory motion. One can imagine the earth slipping from under it, as it were, as it spins round from west to east, so that the current of air flying south would deviate from the straight line and get sent away to the westward.

It would, therefore, blow from the north-east; in the same way, the south wind coming north would be converted into a south-east wind.

Now the prevailing winds between the polar calms and the calms of Cancer are winds which blow towards the Pole, so that the current of air which blows towards the Equator must over-run them—as, in fact, it does until it reaches the thirtieth parallel of north latitude. There it meets with a counter current of equal strength, and the two opposing bodies meeting, cause a pressure or stagnation in the air at the point of contact, the stagnation produced being the calms of Cancer, which stretch over five or six degrees of latitude.

Neither opponent being able to conquer, both winds descend—the north wind to pursue its southerly course to the Equator, the south wind to fly onwards to the North Pole.

The wind which the northern giant met at parallel thirty was a south-west wind, which had blown above and across the extent traversed by the north-east Trade. Its history does not differ materially from that of its rival, except that at parallel thirty it has nearly done its travels, whereas the north wind is only just setting forth.

One wind has made the circuit of the globe, just as the wind it meets will have to make the same circuit. It has started from the South Pole along the upper air road (the procedure is the same in the southern hemisphere as in the northern), has encountered the strong north-west wind which overlies and blows above the south-east "Trades"; has pushed against it so hard as to repeat at Capricorn what was done at Cancer, and has swept resistlessly over thirty degrees of latitude as the south-east Trade Wind. At that distance from the Equator it has been met by the north-east Trade Wind. With the impetus acquired by rushing over a run of thirty degrees of latitude apiece the two winds are hurled at one another, and are forced to scale the heavens in order to avoid each other. Then northward and southward they rush respectively.

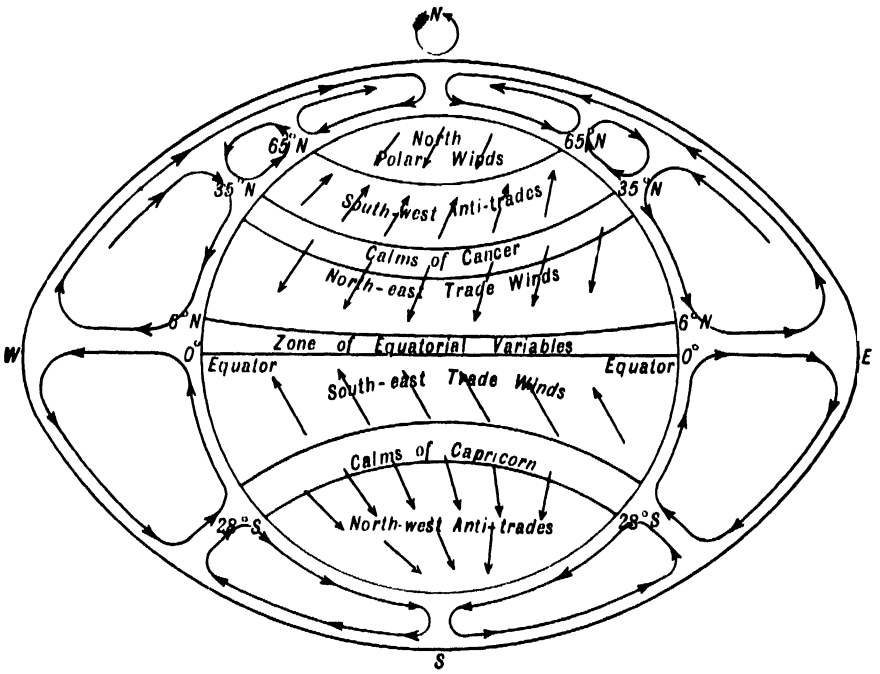


Diagram Showing General Direction of Winds on the Earth's Surface

Steady as the Atlantic Trade Winds are, those of the Pacific Ocean are still more constant. Here the ocean road-makers are found at their best. In the Indian Ocean, however, there is a variation, for Asia, on the north, intercepts the atmospheric currents, and the Trade Winds are constant for the year round only in the southern belt.

Harvesting the Sea

"Captains Courageous"—How they Gather their Silver Harvest from the Depths

By HORACE C. DAVIS

IT has been said that the fisherman is like the poet—born, not made. Perhaps this is true as regards the patient river angler, but the salt-water sportsman does not need to draw so extensively on his patience, for there is exciting work to be had among the eels and the codling round our coasts. There is the deep-sea sailor sportsman, who, with a sturdy harpoon in his hand, crawls to the lower end of the martingale below the bowsprit of a big "wind-jammer," and there hunts the porpoises that play in the undisturbed water just ahead of the vessel's bows. The fish hunter must not fear a sudden ducking as the great ship lowers her nose into the seas, but must for ever keep his eyes open for a rising shadow. When the great curved back comes up, the harpoon must be driven home, and then, between the dripping man clinging desperately to the martingale and the doomed fish, ensues a titanic struggle.

With what pleasure one thinks of bonito fishing, with a bright ship's spoon as a bait, the quick snap of the agile fish, the hauling up of the line, the grabbing of the fighting fellow in a piece of cloth provided for the purpose, and later a bonito steak for breakfast.

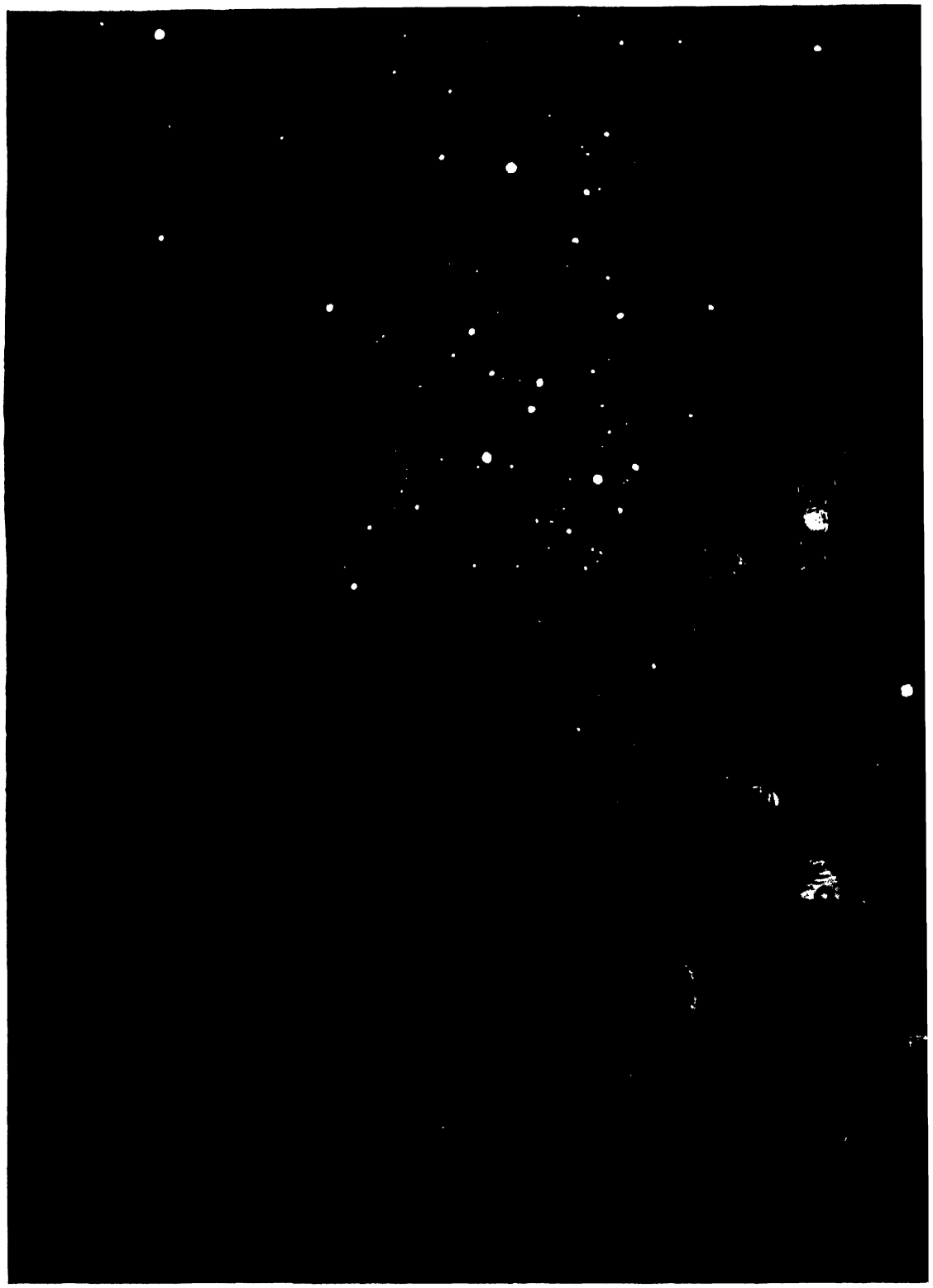
This is only the "sport" of sea-fishing; there is another and more serious side in which men go to sea to secure the finny denizens of the deep to provide themselves and their families with their daily bread. The "tinned-salmon" familiar in households provides a vast number of men and women with constant employment, and in America the industry has now assumed such gigantic proportions on the Fraser and other rivers of British Columbia that huge canneries have been erected and the cultivation of the fish carefully looked after by enormous "hatcheries." On the bleak Newfoundland banks are the fleets of the cod fishers, whose life has been brought before most of the reading world by Kipling's "Captains Courageous."

At home the United Kingdom has a vast fishing industry, in which over 7,000 boats are engaged 1,100 trawlers and 600 oil or steam-propelled drifters being registered at English North Sea ports alone. There are really two great types of fishing carried on in these home waters, one by means of the trawl and the other by the drift net, the former being used for catching the "white" fish, viz., cod, plaice, etc.,

Photo: H. Jenkins, Lowestoft

The Harvest of the Sea

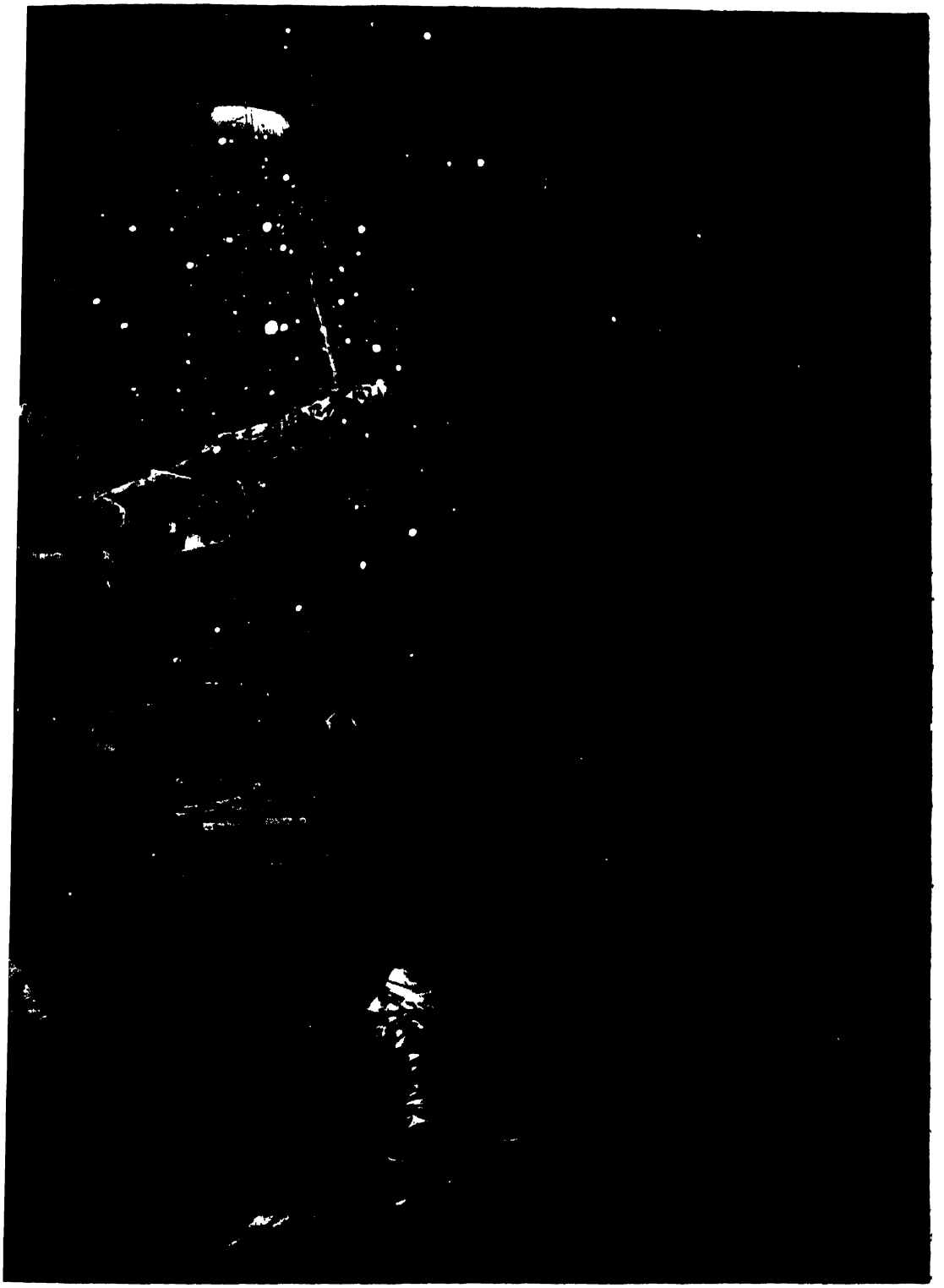
A North Sea fisherman hauling in his nets



DELIVERING BOXES OF FISH ABOARD A STEA

(*Draw*

After its trawl is hauled, each fishing-boat packs the catch in boxes with ice and salt, and sends off its boat
employed in the industry are placed under the supreme command of an "Admiral," v



CARRIER AT NIGHT ON THE DOGGER BANK

F. Matania)

"dory" to the steam carrier, which waits, with steam up, to convey the harvest of the se to market. is as much an autocrat, in his way, as the gold-braided admiral of a British battle-fleet

This Diagram clearly Illustrates the Use of Trawl and Drift Nets

and the other exclusively used for herring. In England and Wales the trawling interest is of preponderating importance; in Scotland, however, it provides employment for only 10 per cent. of the fishermen, and this low proportion is steadily decreasing north of the Tweed. South of the Tweed the increase has been between five and six hundred since 1911.

In trawling the vessel tows a large leg-of-mutton-shaped bag-net astern, which is attached to the boat by a stout manilla warp. This net is drawn along the bed of the sea, and inside is a smaller bag. The fish simply swim or are swept into the mouth of the outer net, and, once in, they are prevented by the smaller funnel-shaped inner net from getting out again. To-day fleets have their regular "grounds" on the Dogger Bank and other favourite fishing places, and are usually owned by large commercial undertakings. The vessels employed are placed under the supreme command of an "Admiral," who is as much an autocrat, in his way, as the gold-braided admiral of a British battle-fleet.

When, at the appointed time, the trawl is hauled, and the silvery struggling masses of fish emptied upon the trawlers' decks, there comes the busy time of "boxing" the fish. "Boxing" is packing the catch in boxes with ice and salt, and then placing them in the sturdy dory—the fishing vessel's only boat—bobbing under the lee of her parent vessel. The dory, once packed with her share of the deep-sea harvest, is rowed to the waiting carrier, lying-to with steam up, ready, when loaded, to hurry away at full speed to market. Other boats of the fleet take their catch into port themselves, where their takings of the harvest are dumped in with the vast mounds of fish and sold by auction in the fish market.

The harvesting of the seas and the labouring of the harvesters go on throughout the year, no matter whether it is a glorious evening in midsummer, when a curious "landlubber" may be aboard, or

Photo: H. Jenkins, Lowestoft

The Old Style of Sailing Drifters

A fleet of old-fashioned sailing drifters in Lowestoft Harbour. These picturesque craft are rapidly giving place to steam-propelled vessels

Photo: H. Jenkins, Lowestoft

And the New Steam Drifters

The hundreds of steam drifters which have been built during the last ten years are largely responsible for the increased activity at our fishing ports. The life of the fisherman is of the roughest, the perils are great, and the risk of financial loss is also heavy Nets worth from £100 to £300 are often lost in a single night

in the depth of winter, when out of the gusty darkness comes the whistling spray that cuts the skin like a knife.

Just as vast is the herring fishery in which the drifter is exclusively engaged. Starting in the Scottish firths in January, the fleet visits North-eastern England during April, May and June, turns slightly north from July to September to give the Berwick and Eyemouth men a chance, and finally goes south to make Yarmouth and Lowestoft hives of industry from October to December.

The Herring Fishery

The method employed is entirely different from the other type of North Sea fishing, for in this case the drift net is used. Each boat will "shoot" one-and-three-quarter miles of nets, which trail out astern of the vessel. The far-reaching nets are buoyed by canvas globes floating on the sea's surface, and are kept hanging, in a perpendicular wall of fine strong cotton-mesh, by the weight of the sole and messenger ropes attached to the bottom edge.

Let us proceed to sea with one of these power-driven vessels to watch the harvesters at their work. Observe, while the vessel forges ahead, how anxiously the crew watch for the unmistakable signs of a shoal. Right ahead on the dark expanse of rolling sea is a gleaming patch like a moon-lighted area amidst dark clouds; that silvery area is the herring shoal, giving off the phosphoric light by which they are known. The order is at once given to "shoot" the nets, and over into the depths of the water, the sixty of them go, each one fifty-odd yards in length, which means half an hour of strenuous work.

When once it has taken up the required position, the vessel is stopped and allowed to "ride" by her nets, keeping them taut by her superior drift. Into this wall of spreading network the herring swim in their hundreds and thousands; pushing their heads vainly through the mesh and getting caught by their gills, they are held fast. In two to four hours' time the steam capstan aboard the fishing vessel begins to haul in the nets with their prize. Anxious eyes watch for what the nets contain, for there is a great disparity in the size of a catch. Two vessels may shoot their nets a few yards from each other, and while one may secure a hundred "crans" (each cran being 870 fish), which at present prices may mean £200, the other boat may be only able to show as many shillings' worth for a night's work.

Then comes the rush to port, where the eyes of the "shore partner" watch for puffs of steam from the syren that tell the quantity of fish aboard, for it is one whistle for every ten cran stowed beneath the deck.

It is now the turn of Scotch fisher lassies, who have followed the white finny hosts from Scalloway in the Shetlands, and Stornoway in the Hebrides, through Fraserburgh, Eyemouth, Berwick, Scarborough, to the great festival of Yarmouth and Lowestoft. Clad in their great sea-boots, the fisher girls set straight their "oily" aprons, and adjusting the wads of cotton that protect their thumbs from the sharp "gutting" knife, stand in all weathers ready at the pickling tub.

With a quick flash of experienced eyes, the Scotch girls deftly pick out the various qualities, and, having removed the gills at almost the same moment, add the necessary salt, and pack the fish in barrels ready for shipment abroad: whilst other women are "gutting" the fish for curing. Working at full speed, the girls will earn eleven shillings in a single day.

To Protect the Industry

Recently, certain trawlers have commenced to trawl herring, much to the disgust of the drifters, who argue that by this method spawn and immature fish will be ruthlessly destroyed, and in time seriously affect the fishing. It is suggested by some of the fishermen that these girls, as a means of protecting the industry, should refuse to handle the trawled herring.

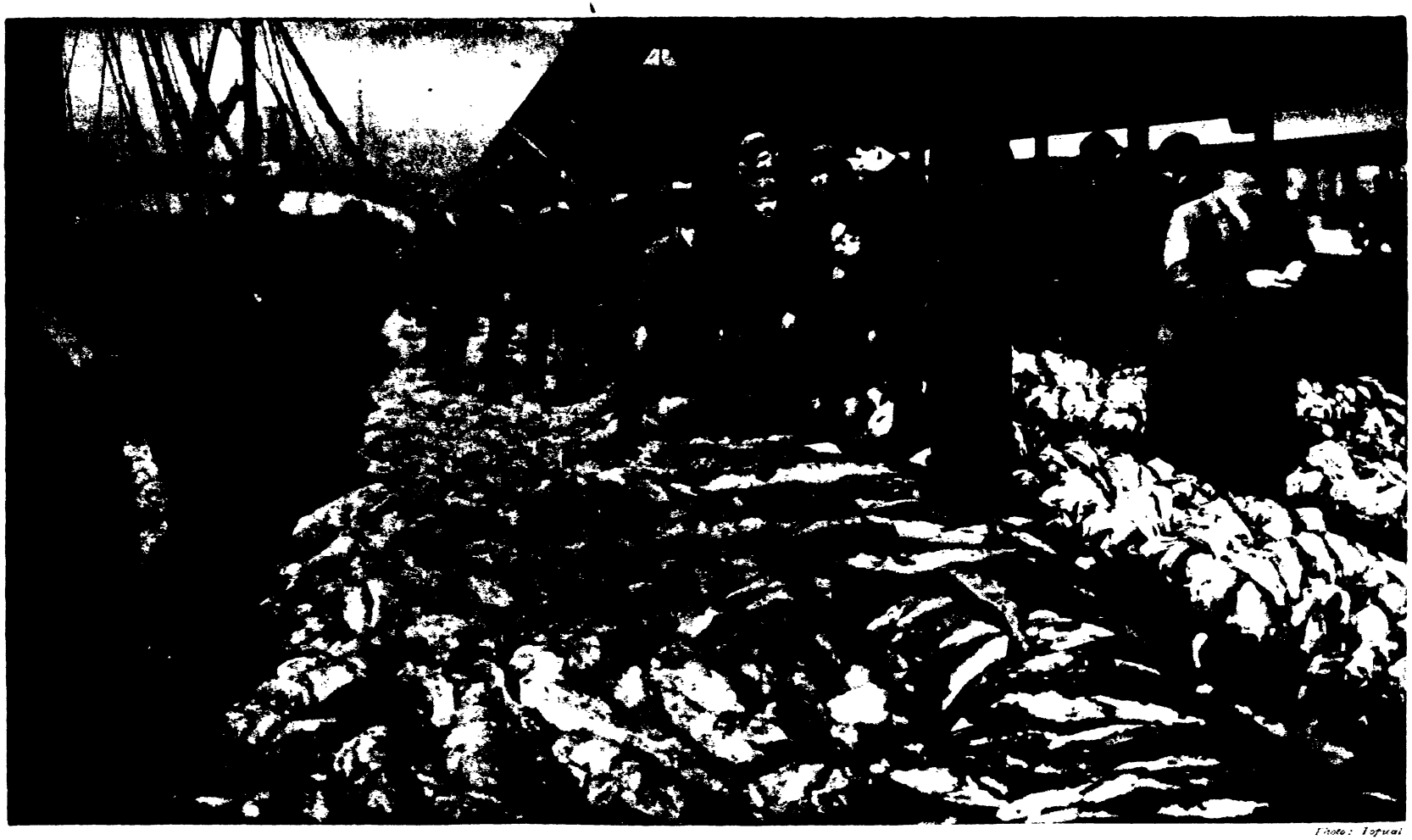


Photo: Topical

Fish for the Easter Market at Grimsby Dock

Immediately before Holy Week the demand for fish, which comes from London especially, keeps all hands busy in the watery fields whence the fisherman culls his harvest. The rewards of enterprise are curiously unequal One vessel may earn £200 in a single night, while another a few yards away will take only 200 shillings

The Mystery of the Pygmies

A "Fable" from the Classics Proved True in Real Life

By E. A. BRYANT

HISTORY, which is never so interesting as when she repeats herself, has within the last few months been duplicating one of her fascinating chapters of surprises. Two stalwart explorers, in Captain Cecil Rawling and Mr. A. F. R. Wollaston, are home from Dutch New Guinea, to tell us of a new race of pygmies that they have discovered there, dwelling on the flanks of the great Snow Mountains. So the frontiers of dwarfdom are thrust back to embrace another domain, and fable comes to life before our eyes.

Ape-Like Men

The twin wonders of modern discovery in the wilds are the great man-like apes and the tiny ape-like men. When King George was born the world still disbelieved Du Chaillu's statement that he had seen gorillas, still refused to credit the existence of such animals; yet Hanno, the Carthaginian navigator, visiting the tropical west coast of Africa in B.C. 850, has recorded his experience there of either gorillas or chimpanzees. It took nineteen centuries to make the mightiest of the primates a creature of real life to the world. The pygmies took rather longer to establish the fact of their existence. The literature of the classics teems with references to them; the folklore of Africa and Asia and Europe bases many of its strangest stories upon pygmy life. Our nursery tales of gnomes and fairies, goblins, pinkies and brownies have undoubtedly come down, generation after generation, by word of mouth, from the dim, primeval days when pygmies wandered dryshod across the land-bridge that connected India with Africa, and when the island of Sicily was part of the highway from northern Africa into Southern Europe. Although no pygmy in the wilds has ever seen pencil or paper, yet the race is immortalised in the company of Trojan and Greek, and until modern times has been regarded as equally mythical. Homer, who lived in the ninth century B.C., began the story, comparing the arming Trojans, rushing to war, with cranes migrating to the pygmies' land:

"So when inclement winters vex the plain
With piercing frosts, or thick-descending rain,
To warmer seas the cranes embodied fly,
With noise, and order, through the midway sky,
To pygmy nations wounds and death they bring . . . ."

Battling with the Storks

Aristotle knew full well of the existence of pygmies; Herodotus describes them as battling with the storks which came to raid their crops. These and other ancient writers got the main fact correct as to the existence of the little people; but, as in other dealings with natural history, they mingled the marvellous with the matter-of-fact. Their tales of pygmies with pygmy horses and other tiny, domesticated animals, of the tiny people having to cut down their crops with axes, of their requiring a ladder to mount into the goblet of Hercules, were, of course, as fabulous as the legend of their fashioning the spear of Odin and the world-shaking hammer of Thor. And because of this

The Battle of the Pygmies and the Storks

Although Homer, Herodotus, and other ancient writers referred repeatedly to the existence of pygmy races—which they represented as waging desperate warfare with the storks that came to raid their crops—until quite recently the modern world refused to credit the existence of such miniature people. Now, however, various expeditions have proved their existence in several parts of the globe, and they have even toured the world on exhibition

leaven of romance the whole story of pygmies was discredited. It was not until Schweinfurth, Livingstone, and Stanley burst into the twilight gloom of the African forests and discovered these little relics of the days before history, that the kingdom of the midgets swam into the ken of the world. They have been in the world, but not of the world, unchanged, undeveloped, since their larger fellows emerged from the caves, or dropped from the trees to make themselves habitations on the ground and set up the first of civilisations.

African Pygmies of the Border Regions

They have been in the world, but not of the world, unchanged, undeveloped, since their larger fellows emerged from the caves or dropped from the trees to make themselves habitations on the ground and set up the first of civilisations

It seems almost incredible that these most interesting of all savage peoples, living a specialised life, governed by their own peculiar laws, speaking their own isolated language, should have existed throughout the ages, without their presence on the earth being known to mankind in general. For pygmies, although divided by ethnologists into but two groups, Negrillos and Negritos, are many in point of both tribes and numbers. We find them in the Andaman Islands, in the Bay of Bengal; we have half a dozen distinct tribes of them in the Congo; we have the tiny Bushmen of South Africa, the ancient Aetas of the Philippine Islands, the Samangs of Malacca, and pygmy tribes in the Solomon Islands in Formosa; and now these little images in Dutch New Guinea. Sir

The Pygmies

Ray Lankester holds that the Veddas of Ceylon—perhaps the most primitive human beings on earth—the Toalas of Celebes, certain tribes of Beloochistan, and the "monkey-men" of Bandra-Loks, east of the Indus, belong also to the pygmy tribes.

Was Herodotus wholly inaccurate in describing his pygmies as defending their crops against great birds? Conventional views are against him, not so much on the ground that cranes and storks are water-frequenting birds as on the ground that pygmies are always declared by modern observers not to cultivate crops; but the latest discoveries in Dutch New Guinea are on the side of the ancients. The Tapiros, as the newly known midgets are called, do cultivate crops. They cultivate sweet potatoes, tobacco, and sugar-cane. This fact constitutes rather a "facer" for those who, arguing from particular to the general, have laid it down that the midgets of the wilds never cultivate, never have cultivated. There is still a chance that Herodotus was right! African pygmies of to-day have no crops, it is true; but they do wage war upon the giant cranes which haunt the head waters of the Nile.

Photo by Sir H. H. Johnston

A Pygmy Woman

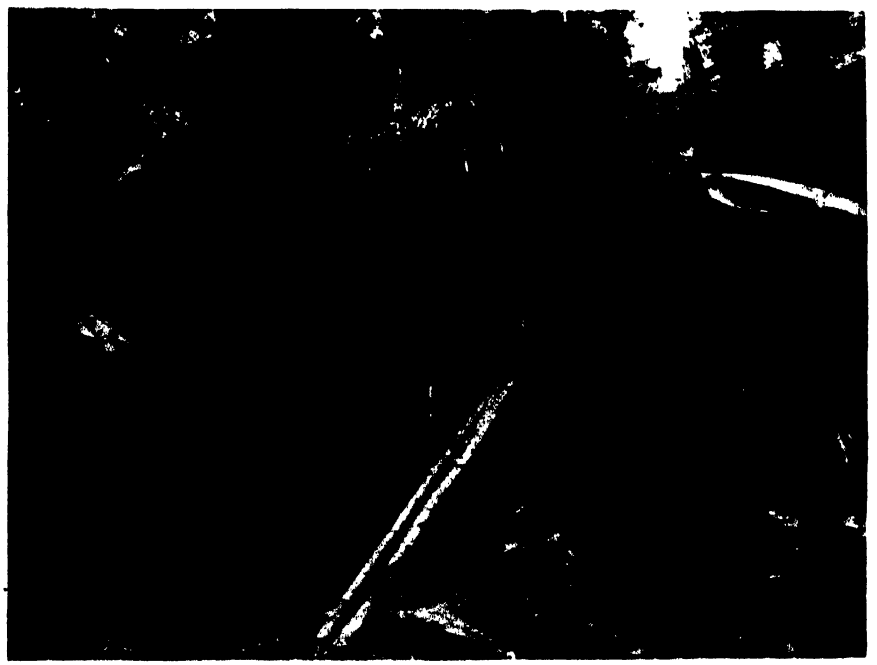
Although modern travel has caused the book of hidden men's lives rapidly to expand its chapters, over thirty years have elapsed since the first pygmies were seen in Europe. Two were brought to Naples by the traveller Miani, who got them in the Mombootoo country, south of the Welle River and west of the Albert Nyanza, in exchange for a dog and a calf. They flourished upon kindly treatment and good living, and eventually reached the staggering height of 4 feet 8 inches. Then we had no more real pygmies in Europe until Colonel J. J. Harrison brought six—four men and two women—to London in 1905. The scientific world had never been so stirred since the first anthropoid ape made its appearance in England. Their height ranged between 4 feet and 4 feet 3 inches. They knew the use of fire and, in a primitive way, iron-smelting and working. Their spear-heads are of iron, smelted and worked by themselves, and the tips are poisoned with a virus of terrible potency. They live in tiny huts in the forest—huts only 4 feet in height, bare of any suggestion of furniture, and entered by a low opening through which the tenant crawls on all fours. Spears are their only assets. These constitute the purchase price of a bride, and upon the product of the weapon they live. They attack and kill the mighty elephant; they hunt the okapi. It is a strange fact that the discovery of the Congo pygmies gave this extraordinary animal to the knowledge of the world. No white man had ever seen an okapi ten years ago, and only rumours of its existence had been heard. And those rumours suggested that the unicorn of heraldry and legend really lived. The forest-living pygmies alone knew of the real animal, and when photos of the

strange beast were at last exhibited in London and it was desired clearly to fix the name, the pictures were shown to pygmies, who at once exclaimed "okapi."

At home the pygmies are feared and avoided by other natives. They inhabit the reeking, steaming forest, impenetrable to all save themselves, and pass their lives in a perpetual twilight, amid mighty trees laced and bound together with vast, interminable creepers, in and out of which little men run like rabbits. They are perfectly naked, save for a loin covering of skin for the men and a costume for the women precisely resembling that of Eve. They are cleanly in their habits, affectionate in family relations, loyal in marriage. Contrary to report, they are not cannibals.

The same habits and method of living distinguish the majority of pygmy tribes. For the most part all have features in common: the dark skin, the ape-like mouth; the broad, flattened nose; the woolly, "pepper-corn" hair. In some the body is covered with a woolly or downy hair, and Dr. Edgar Geil, a traveller of note, when exploring unknown parts along the Great Wall of China, heard of hair-clad pygmies said to be descended from pygmies of twenty centuries ago, who fled to the wilds to escape forced labour on the Wall. Apparently the superstition which now protects the pygmies from their neighbours was not so active in ancient days, for China was not the only land in which the attempt was made to enslave them. They are represented on some of the earliest Egyptian sculptures, and there described as Akkas, a name still applied to the best known of the Congo pygmies.

Like the tiny Shetland ponies and the diminutive Shetland sheep dogs, the pygmies make up in intelligence what they

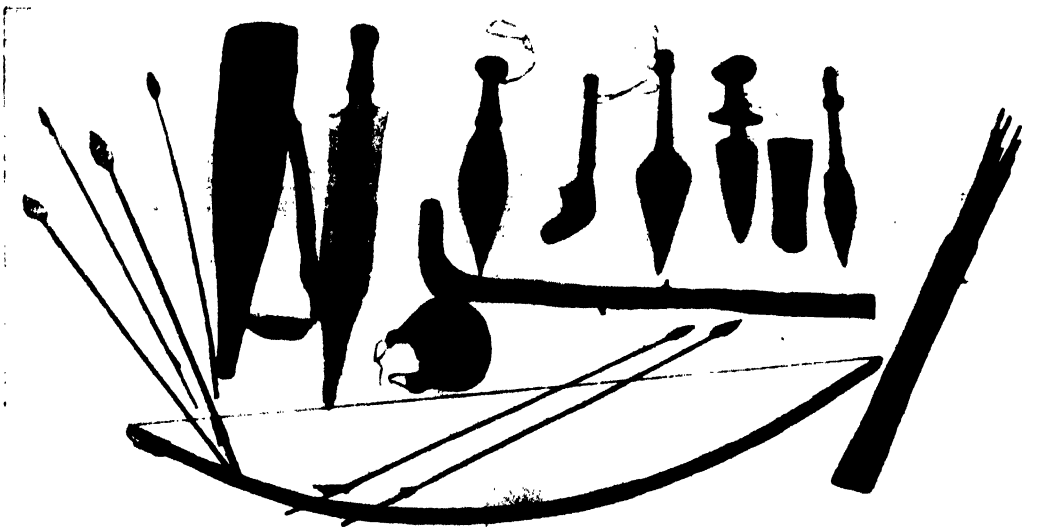


A Pygmy Home in Dutch New Guinea

This photograph (one of those taken by the British Ornithologists' Union's expedition) shows a typical house in a pygmy village. It is built on piles and lined with bark to keep out wind and rain

lack in inches. This statement seems hard to reconcile with the fact that the life of an African pygmy to-day is pretty much what we may imagine that of a Neolithic man to have been. But the fact that they have so long managed to hide and thrive where other races have been blotted out is in itself a tribute to their cunning and adaptability. Small men, lacking intelligence, would have been spoon made of the shoulder-blade of a pig or other animal.

These little folk fashion knives with hard stone blades which take so keen an edge that they can cut tough bamboo, while axes of similar material enable them to cut wood for fuel and other purposes. Yet, with all their progress—and fire-lighting and tool-making and the cultivation of crops represent miracles in the



A Collection of Pygmy Weapons

The pygmies fashion knives with hard stone blades which take so keen an edge that they can cut tough bamboo, while axes of similar material enable them to cut wood for fuel and other purposes

exterminated centuries ago, whereas pygmies are abundant.

But the pygmies most recently discovered—those of Dutch New Guinea—appear to be in advance of their fellows. As we have seen, they are husbandmen, growing their own crops. They make bows and arrows, and use them with astonishing skill, employing them against birds, rats, mice, and other small animals.

Nor are larger game immune. They must number wild pigs among their victims, for Mr. Wollaston records that the little people, after roasting their sweet potatoes, scoop out the inside with a isolated savage—they have not discovered the use of clothes. So horrified, indeed, were they at the habiliments of the white men that they hid their women and children, telling Captain Rawling, in the end, that if he and his party discarded their clothes and appeared decently naked like the pygmies, the women might lose their sense of terror and return to behold them. These unclad midgets live some thousands of feet up the mountain side, where the temperature at night is very low, yet clothing has no meaning for them.

Mr. Wollaston met another tribe, apparently, of midgets, whose height exceeded by some inches that of other pygmies of

the mountain, yet did not exceed 4 feet 8 inches. They were less shy than the others, and hearing, as savages do hear from afar, of the approach of the white men, set out in numbers from the mountains to the lowlands to visit the pacific invaders.

The sequel to this courageous visit—for the approach of such tall and queerly clad strangers must have been very terrifying to the forest people—is tragic in the extreme. In their excitement the little tribes even neglected the most ordinary precautions of the march. They carried no food with them, and upon the return journey some thirty or forty died of starvation on the way, the country being barren of food. It is no land of plenty where the pygmies live, but all around is such absolute sterility that even their moderate appetites failed to find satisfaction. How came they, then, first to reach the place in which they manage to find a living?

Bougainville, in the Solomon group of islands, has a race of mountain pygmies whose customs seem as strange and primitive as those of the most fantastic yet recorded. Periodically they descend from their fastnesses to the coast, carrying a number of pipes made of bamboo. They fill the pipes with water and carry it back with them to evaporate, and so yield them salt which they cannot otherwise obtain. They imagine the sea to belong to the coastal tribes, and bear with them, in payment for the water taken, a certain black pigment obtained in the mountain interior, and used by the natives upon the seaboard for decorative purposes.

The world is getting, piecemeal, the strange story of its little peoples. Some day the whole book of pygmies will have to be written. It will have to be shown that though they may never have pinioned Hercules—an army of midget warriors to each celestial limb—there is a great measure of truth in the story of a real forerunner of Gulliver in a real Lilliput.

Photo by Sir H. H. Johnston

A Pygmy Man

The pygmies inhabit the reeking, steaming forest, impenetrable to all save themselves, and pass their lives in a perpetual twilight, amid mighty trees laced and bound together with vast, minable creepers, in and out of which little men run like rabbits

A 25-ton Door, the Strongest in the World

This round door in an American safe deposit is 7½ feet in diameter and just over 23½ feet in circumference. Its twenty-four round bolts each weigh 100 lb., and it is fitted with four time-locks. An army could not open it except in the proper way

How Science has Devised Impregnable Strongholds where Wealth may be Stored without Fear of Burglars

ALTHOUGH much has been written about safes, little has been said about strong-rooms. The reason for this is not difficult to seek. It is principally in the banks, insurance companies, and the safe deposits that we find these giant rooms of steel, and naturally these institutions are not particularly anxious to let all and sundry know the secrets and strength of the devices they have erected for the safeguarding of their bullion and treasures.

Nevertheless, it is possible to record the history of the strong-room, and a fascinating history it is. It had its birth scarcely more than one hundred years ago in the great oak boxes, clamped with iron and provided with formidable clasps and locks. In the Bank of England's museum may be seen an old oak chest which was the Old Lady of Threadneedle Street's first strong-room. It is little larger than a common seaman's chest, and in this the Bank stored its cash, notes, and valuable papers.

It was not long before man's faith in the strong-boxes of oak was rudely shattered by the ease with which the burglar of those days opened them with a fine saw and chisel. Then came strong-rooms built of bricks, followed by still stronger receptacles erected of hard Staffordshire blue bricks laid in cement. The openings into these chambers were gained through strong iron doors possessing heavy bolts and locks. But the burglar got through them. To make them, as they thought, absolutely burglar-proof, the vault-maker built the entire room of steel, the opening consisting of a double door having two locks, double hinges, and many other ingenious contrivances calculated to daunt the most persevering thief, and force him to admit that, at last, here was something he could not break open. Special steel plates were made, possessing great hardness and toughness. This was to resist the vastly improved drills and "jemmy" of the burglar.

Strong Rooms

Strength Personified

An electrically protected rectangular door in an American safe deposit

The latter at once called science to his aid, and showed how he could attack and beat down the defence by a small pinch of nitro-glycerine ingeniously applied and carefully exploded. The vault-maker then turned his attention to armour-plate, and erected his strong-rooms of this metal. Yet again the burglar was successful. He produced a new cutting tool which did the work with even greater ease than dynamite or nitro-glycerine. Now, here was a problem; the burglar had shown his ability to cut through steel plates with ordinary ease, and to turn out something that was absolutely proof against all his devices was indeed a difficult task.

Yet, the vault-maker would appear to have at last succeeded, and it is the boast of these experts that many of the strong-rooms found in the more up-to-date safe deposits, banks, and other institutions are not only burglar-proof, but proof against attack from armed mobs and also from earthquake shocks. Their great steel walls are absolutely undrillable on account of the hardness of the metal employed, while by welding the plates together it is virtually impossible to burn through them. Then by means of time and combination locks it is impossible to open the doors without the key, and a knowledge of the combination, once they are closed. As a further precaution many of these strong-rooms are so designed that an electrical alarm is sounded should attack be made upon them, or the basement in which they are situated is flooded with water the moment their mechanism is tampered with.

It is in America that the construction of strong-rooms has been developed to a fine art. Take, for instance, the Carnegie Safe Deposit vaults recently completed in New York. From first to last they took two years to build and cost over £100,000. The vaults here are in reality two huge steel boxes, placed one above the other in the basement of one of New York's latest skyscrapers. The lower one is 180 feet long, 31 feet wide, and 10 feet high, and the upper one 85 feet long, 20 feet wide, and 10 feet high. They are made of the best Harveyised nickel-steel armour-plate. In

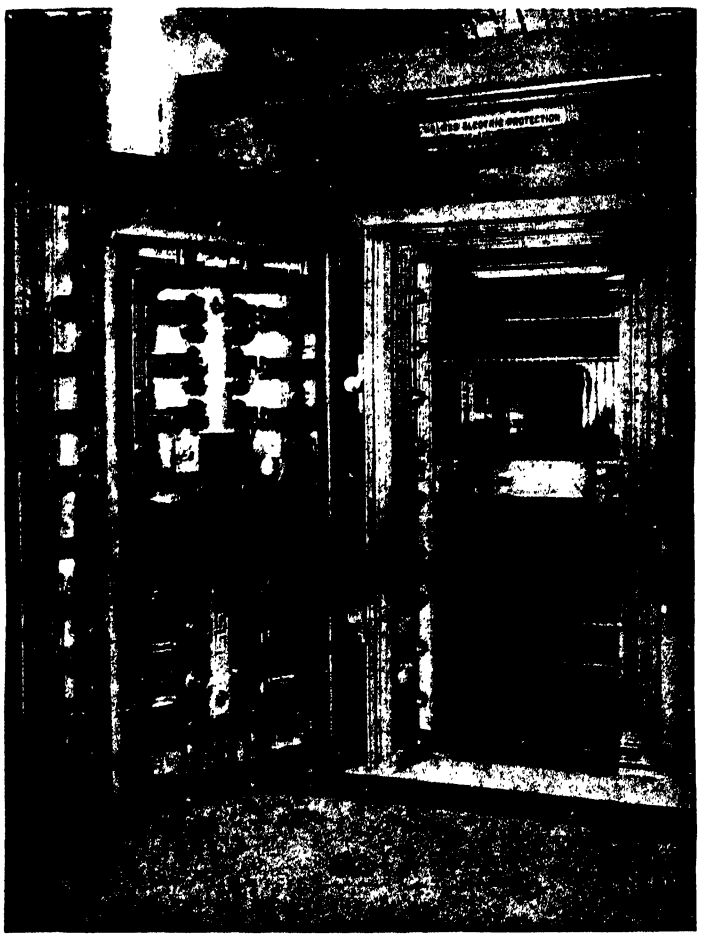
all, some 1,400 tons of this metal was called into requisition, a greater quantity than is used in the construction of a modern warship. None of the plates of which these vaults are constructed weighs less than five tons, and some of them turn the scale at 50 or 60 tons apiece. Indeed, the two biggest plates are the largest pieces of armour-plate ever forged for any purpose.

These plates, which form the shell of the vaults, are 5 inches thick, except at the openings for the doors, where the armour is 18 inches thick. No bolts or rivets were used in the construction of these strong-rooms, the plates interlocking into each other by means of wedge-ends and channels. This means that the completed structure is, to all intents and purposes, one solid piece of metal, and any force applied to the joints has only the effect of tightening the grip of the wedges.

As a further precaution, a fire-wall of concrete, 12 feet thick, was laid around the vaults, except, of course, at the doors. Then, underneath, comes the foundation, which consists of 10 feet of alternate layers of concrete and rails, laid flange to flange, built up from the solid rock.

Access to these strong-rooms is gained through two round doors. They weigh 25 tons apiece, and are the largest and heaviest round doors ever made. Twenty tons of this weight are in one solid mass of material, 7½ feet in diameter, while the remaining 5 tons are accounted for in the bolt-work and mechanism operating the lock. There are 24 round bolts in each door, each weighing 100 lb. An electric motor hung on the inside of the door gives the power to the gear which operates these bolts. With the precision of a clock these steel fingers grip the neck of the vault when the door is closed, not to release their hold until the appointed hour, when the time-lock has run the course set at the closing of the door.

There are certainly some wonderful strong-rooms in the various safe deposits found in Great Britain. The oldest of these institutions is the National Safe Deposit, situated in Queen Victoria Street, within a stone's throw of the Bank of England. Here are to be found 32 great armour-plate vaults, built up in four tiers. It is a

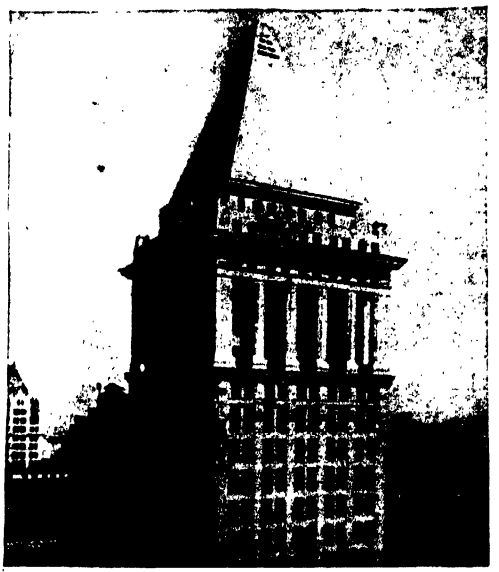


The Same Door Open

It weighs 20 tons and throws 24 bolts, weighing 100 lb. each

veritable stronghold, which no burglar could ever hope to penetrate; even if he rained the most powerful explosives upon it, it would still remain intact.

The outer walls are 18 feet thick. Then comes a passage, and thick walls again, lined inside with armour-plate dove-tailed in sections, and strengthened by wrought-iron framing. The massive steel doors leading to the vaults, or strong-rooms, are 12 inches thick, and weigh close upon 5 tons apiece. They possess no locks, and are closed and opened by hydraulic power. After the machinery which operates these doors has fulfilled its duty at night, it is disconnected, and should anyone attempt to reconnect it they would release the water in the cistern above the vaults, which would mean that the whole place would be flooded and the would-be robbers drowned like rats in a trap, unless promptly arrested.



The Home of the Pierpont Morgan Millions
In the pyramid on top of the Bankers' Trust Building, New York, are 47 fireproof storage rooms in which the Morgan millions are kept

Much the same would happen if a mob overcame the guards and "watch clerks" at the Bank of England. They could not penetrate into the vaults, for their passage would be blocked by large reservoirs of water. The strong-room here is one of the largest in the world. The foundation, 60 feet below the street level, is a bed of concrete 20 feet thick. Above this concrete is a lake 7 feet deep, and, above that, thick plates of iron, specially manufactured to resist both skill and force. Anyone attempting an entrance from above would find a similar bed of concrete, a similar lake, and similar plates of iron. The walls are impenetrable, while the doors are 1 foot thick, weigh 4 tons each, and are made absolutely undrillable.

In one of the New York banks steam pipes run along the passages, from which, in case of riot and an attack upon it, jets of hot steam could play upon the strong-room, scalding the assailants. An equally remarkable device, for immediately announcing the presence of an interloper and enterprising burglar, is the tell-tale disguised tinfoil curtain, with which electrical wires are connected from the janitor's room in the upper part of the building. Pressure upon the wall of the strong-room will set the bells ringing, and promptly announce the presence of would-be thieves. In some of the devices, too, not only are gongs set going, but the electric lights in the building are automatically turned on.

In the more modern safe deposits these additional precautions are not resorted to. At night, after the strong-rooms are closed and bolted, the passages which entirely encircle the vaults are patrolled by armed guards. How popular these institutions have become, and to what extent the public make use of them for storing their valuables, may be gauged by the number now in existence. There are fourteen in London alone (one with 40,000 strong-rooms and safes), and several in the provinces.

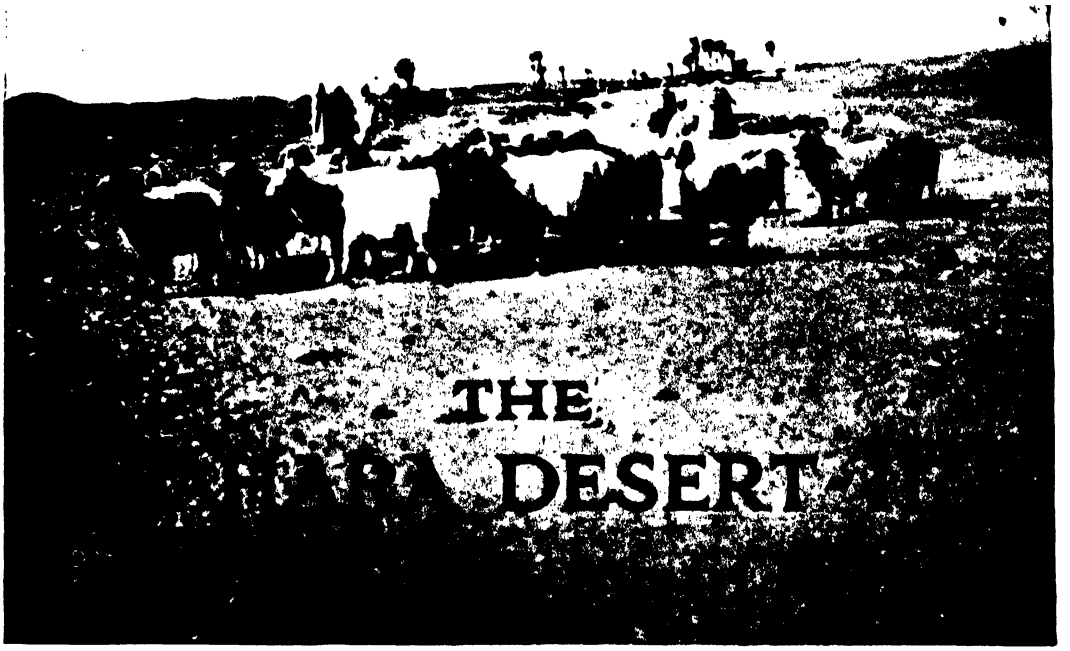


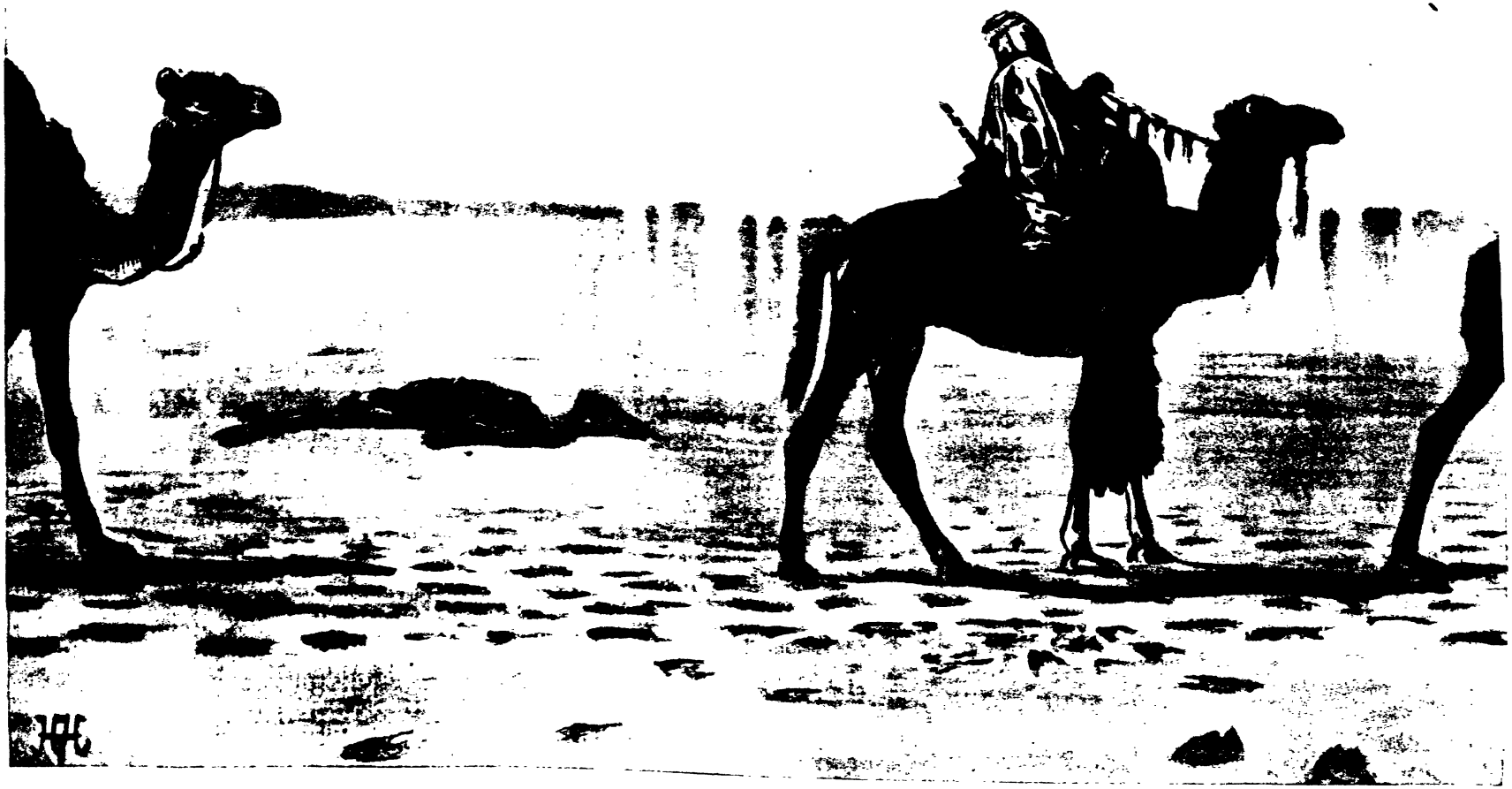
Photo: Sir H. H. Johnston

**The Mirage—Hades and Paradise Conjoined—
Man and Beast in the Desert**

AMONG the natural phenomena connected with the Sahara (and other deserts) which has seized on the popular imagination is that of the mirage. The sand, abnormally heated by the fierce sunshine, sets up a current of heated air which expands, and has its refractive index altered in such a way as causes it immediately above the sand or rocks to become a mirror. Distant objects seen through this air are enlarged and doubled, and the reflection of the sky on this surface of sun-baked ground appears like a lake. It is possible even that objects below the horizon are refracted upwards and made visible, so that fantastic pictures are formed out of the most dreary, objectless vista of sand or rock.

The representations of lakes, bordered with bluish blobs which look like palm-groves or masses of umbrageous trees, are so real as to deceive the very elect. Apparently, also, the mirage is visible to the sight of horses, oxen, and camels, who are allured by the deceptive suggestion of distant water.

The only feature about the mirage which is suspicious is the very indeterminate edge of the water in the middle distance; you never see a well-defined shoreline on the nearer side of the supposed lake. But as this appearance occurs along the shores of real sheets of water in the Desert, and is due to the glare of the sun on the wet sand or mud, it seldom disturbs the illusion of the mirage. I remember once riding in the Tunisian Sahara and approaching a real lake or Sebkha, surrounded by palm-groves and lines of hills, yet taking it to be a mirage, so like did the view appear to the phantom vistas of woods and water which had occurred at intervals throughout the hot day. The surprise in this case, when the prospect was found to



The Mirage

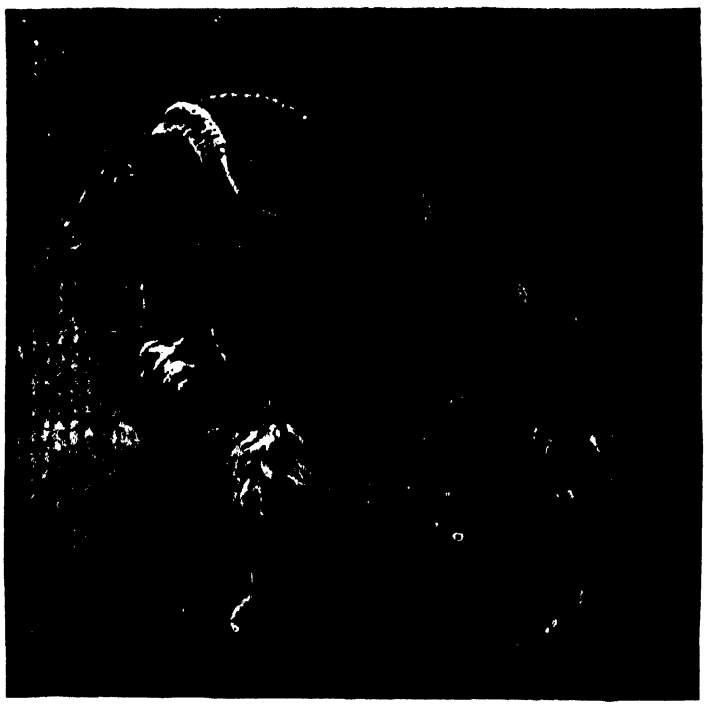
(Drawn by Sir H. H. Johnston)

Fantastic pictures are formed out of the most dreary, objectless vistas of sand or rock. The representations of lakes, bordered with bluish blobs which look like palm-groves or masses of umbrageous trees

be actuality, was correspondingly delightful, for we had had a journey of sixty miles without water either for the camels or the horses, and suddenly to ride into a veritable earthly paradise was the rare realisation of a seemingly impossible wish.

The Sahara Desert does again and again present the vivid contrast of Hell and Paradise. Dotted over the blazing desert (wherein the fierce heat of the day is, throughout the winter half of the year, balanced by the freezing cold of night) are numerous, large and small, more or less historic oases, regions in which springs bubble up out of the sand or the rock, or wherein wells, sunk to a short distance, tap a never-failing supply of water. Some of the springs may be hot and fresh, others cold and salt; but even these last, where they form brackish lakes and pools, to some extent nourish bird life and wild beasts, or assist vegetation by the moisture which is distilled from them through evaporation. Even if the surface water is salt or brackish, it is usually associated with underground supplies of water that are fresh enough to nourish an abundant vegetation.

I scarcely know, the wide world over, any sight more grateful to the eyes, more abounding in the picturesque, than the great river courses of the Sahara Desert; wherein, though there may never be running water, except perhaps once in seven years, when exceptional rainstorms on the mountains turn the river-beds into torrents, there is almost always water at varying depths below the surface of boulders or sand. From this moisture clumps of palm-trees, acacias, tamarisks, or pistachios, derive nourishment, so that they spread out in a greenery which is in beautiful contrast with the bare, often brightly-coloured rocks, and the glaring white stones and pebbles. Under their shade many plants and grasses grow and flowers bloom, and butterflies and birds disport themselves. Occasionally there are open pools of water fed by underground springs, and to these come at night—the brilliant moonlight or starlight of the



Drawn by Sir H. H.

The Big Wild Sheep of the Sahara Desert

Sahara—the big, red-brown desert sheep or the shy Addax antelopes or gazelles.

The fauna of the Sahara still includes (though they are steadily becoming less owing to the attacks of native and European sportsmen) one species of hartebeest—the Bubal, or the wild red cow of the Arabs; the Addax antelope, with its spiral horns; the Leucoryx, with very long horns curved like a slender scimitar; two or three species of the smaller types of gazelle, and the handsome long-legged, long-tailed, long-necked Mhor gazelle, boldly coloured in reddish-brown and white, and figuring a

Photo by Sir H. H. Johnston

The Mhor Gazelle

Handsome, long-legged, long-tailed and long-necked, the Mhor gazelle is boldly coloured in reddish-brown and white

good deal in the drawings of prehistoric man. There is the great desert sheep (*Ovis lervia*) already referred to—the Udad of Algeria, Morocco, Western Egypt, and Tibesti. There are several species of desert mice and rats, and one or two large rodents allied to the porcupine group. There are the striped hyena and the North African jackal; the chita or hunting-leopard; the Caracal lynx. The lion, apparently, is now only found in the Air and Asben mountains in the southern Sahara, and it may also linger in the mountain country of Tibesti and far to the west in Adrar. It is still open to doubt whether a real wild ass still exists in the Sahara Desert, no proof having yet been sent home that there is such an animal, though it is often talked of by the Arabs and Tuaregs.

As regards birds, there are huge vultures of several species, and one or two desert eagles; there are (in the south) black and white ravens; there is, of course, the ostrich. There are sand-grouse and turtle-doves, bustards and cream-coloured coursers. The scrubby hill regions on the verge of the Sudan contain flocks of guinea-fowl and crowned cranes. The birds most commonly seen in the desert regions are black and white chats, grey and fawn larks, and buntings. One of these is an exceedingly pretty little bird, which is apparently peculiar in its range to the northern Sahara between Tripoli and Morocco. This is most abundant in the far south of Tunis, and is called by the Arabs, Bu Habibi, "the father of my friend." It is even tamer than the robin, and especially delights in frequenting human habitations. Its coloration is a blue-grey head and breast contrasted with the bright chestnut of the rest of the body and wings.

The human races of the Sahara and Libyan deserts at the present day consist of three main types; the Tuaregs, the Tibbus, and the Negroes. The Tuaregs are from every point of view the aristocrats of the desert. They represent a Berber population which, about 2,000 years ago, began to penetrate and conquer the Sahara Desert between Mauretania on the north and

Photo by Sir H. H. Johnston

The Addax Antelope

Though becoming steadily less owing to the attacks of native and European sportsmen, the Addax antelopes, with their spiral horns, are still included among the fauna of the Sahara

Nigeria on the south. The very tribe that once gave Africa its name (Avriga, Afrika) and dwelt on the east coast of Tunis, migrated in the course of centuries to the very heart of the Sahara, the Ahaggar region, where their descendants are still known by the clan name of Aurigha. The Tuaregs when of pure blood are a very handsome people, tall, shapely, and resembling the best types of Southern Europe. They are, of course, closely allied to the Berbers of Algeria. The Tibbus, on the other hand, though they vary much in type, and some of them are like Somalis in appearance, have a great deal more negro blood in their veins, and are very dark in complexion. The Negroes, inhabiting the oases and countries like Air and Damerghu, are either of the Songhai or Hausa stock. In the far west —the Atlantic regions of the Sahara—there is a good deal of Arab intermixture, which, together with negro blood, has created a black type of Senegalese Moor, speaking a much corrupted form of Arabic.

A Tuareg Man

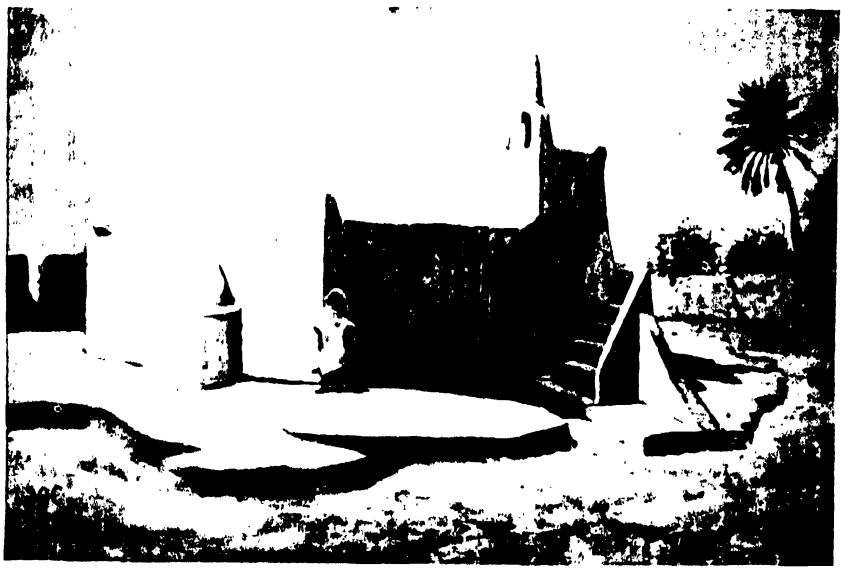
(Drawn by Sir H. H. Johnston)

The Tuaregs are the aristocrats of the desert. They represent a Berber population which, about 2,000 years ago, began to penetrate and conquer the Sahara

In the Tunisian and Tripolitan parts of the Sahara, more especially in the region of limestone formations, there are the celebrated cave dwellers whose habitations were first described by Greek geographers before the Christian era. In Southern Tunis the cave dwellings are of very great interest, as they range in style from the almost untouched cavern, associated with the habitation of prehistoric man, to the elaborate, elegantly-shaped, and furnished dwellings carved out of the heart of the limestone rock. One can see here illustrated, almost as might be arranged in some ethnographical exhibition, the genesis of the house which is carved out of the rock instead of being merely constructed by the placing of one stone on another. We have first of all the rock shelter. This is too open in its natural condition, so its sides are built up with stones and sticks to make it less draughty and more defensible. Then, as its accommodation proves insufficient, its inhabitants have taken to cutting into the soft rock and excavating it in course of time to a more commodious dwelling. Then it has occurred to them, at a later stage, to create these dwellings without any natural beginning. First they would take advantage of some great smooth wall or cliff of limestone rock and cut a tunnel into it, and from this tunnel they would gradually enlarge and excavate a whole series of apartments. In course of centuries they became so adroit and found the limestone so easily carved and yet becoming so indurated when exposed to the air, that they not only planned the excavation of fairly large and high apartments, but as they cut them away they designed and left portions of the rock, which they carved into beds, tables, brackets, and

stools, so that nowadays, if this style of house is adopted and planned, the architect-excavator carves the apartment with all its furniture, which, of course, is literally a fixture.

But another style of underground dwelling that, on the whole, is the most popular and commodious at the present day in the Tunisian Sahara, was not made by carving at right angles into a vertical surface, but downwards into a horizontal surface. The people chose some extensive region of flat limestone rock, and first of all excavated a very large square space, just as we might, in course of time, make a square chalk-pit. Then, starting at a distance of a hundred yards or so, they excavated diagonally a large tunnel which should lead along a gentle incline from the surface of the ground into the bottom of this deep excavation. These tunnels have to be high enough for camels to pass down them. From the bottom of the first square excavation, which serves as a kind of hall or courtyard, they carved out a number of apartments all round. These derive their air and light from the central, square courtyard. The charm of these underground dwellings is that they maintain an equable temperature all the year round. In the summer they are cool, in the winter they are warm—so warm that though it may be freezing hard on the ground above, they need no artificial heat to be comfortable down below. Being in the Sahara Desert, they are always dry, though perhaps once in a way there comes a rare downpour of rain which for a time covers the floor of the central courtyard with water; but this is generally drained off by one or more shafts excavated downwards into the rock.



A Desert Mosque in the Tunisian Sahara
(Drawn by Sir H. H. Johnston)

These strange, rock-hewn, north Saharan cave dwellings seem to be as healthy as they are comfortable. In some of them there is actual elegance in the appointments. On the marble-like floor are disposed handsome rugs and mats, and screens of beautiful tracery are made of pierced walls of rock which separate the private apartments from the central courtyard.

A Huge Lake of Oil Created by the Lakeview Gusher, which Yields over 40,000 Gallons a Day

The Romance of the Oil-fields

Colossal Fortunes Behind a World-wide Industry —What a Derbyshire Village Gave to Mankind

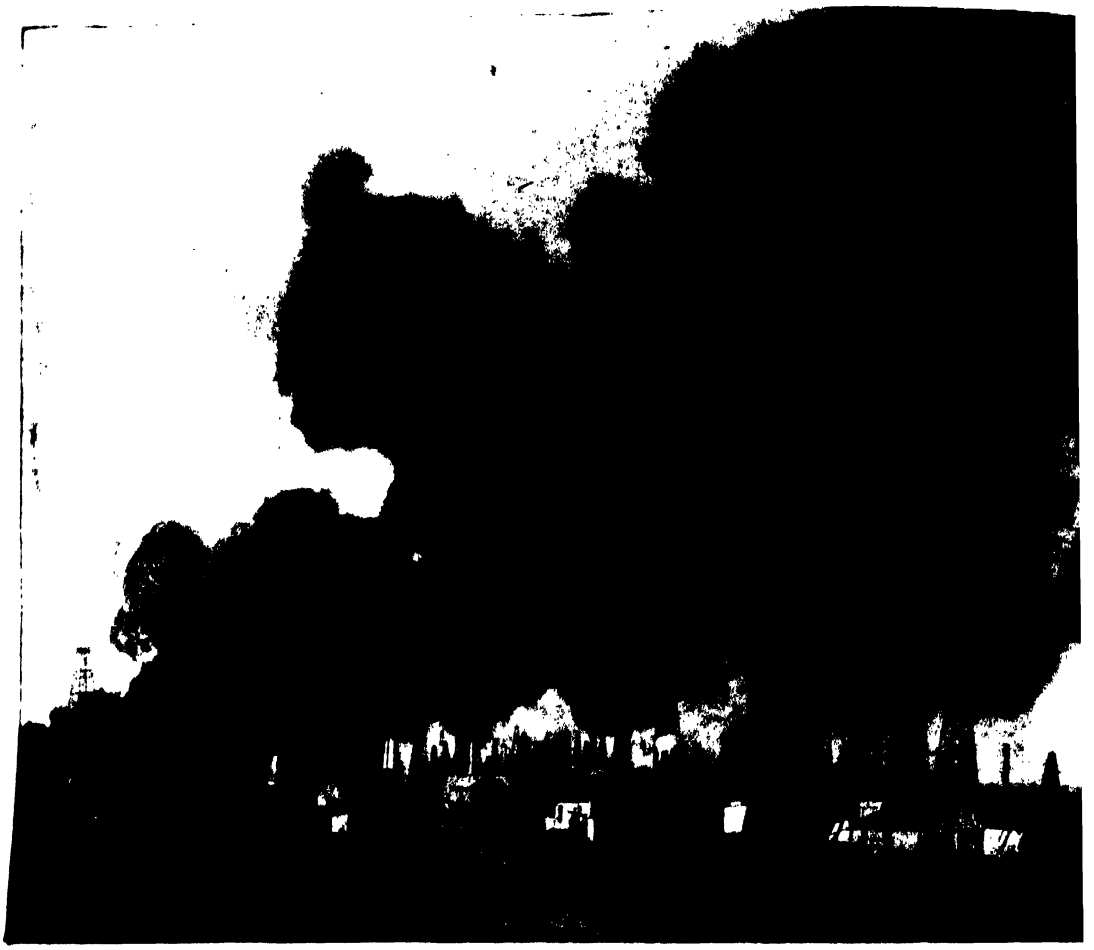
By E. A. BRYANT

Author of "The New Self-Help"

IF Cræsus were alive to-day he would no longer be the magnet to draw the wise men of the world to his golden court. An oil king would buy him up, and keep his Lydian kingdom for a playground. If Monte Cristo lived anew, Dumas, instead of writing a two-volume novel of his adventures, would dismiss him in a paragraph as a successful seeker after a relatively limited buried treasure.

We count fortunes now in figures which anciently had no meaning. The wealth of Monte Cristo is represented nowadays at a single ball given by the wife of an American millionaire. Dumas' hero, it is estimated, had short of two millions sterling, and lived upon his capital; your modern man of fortune derives *yearly* a greater sum from his investments than the emancipated Count ever handled. The income of Mr. Rockefeller is estimated at from three millions to six millions per annum, and his subordinates count their yearly gains in millions sterling. The oil kings are the richest men in the world, the wealthiest, most powerful men that humanity has known. Now, every farthing of their wealth comes to them from the industry created by one man in a little Derbyshire village.

Petroleum is a king of increasing powers. It is difficult accurately to estimate the actual output from the fields of the world.



1. One of the Most Serious Oil-field Fires on Record. The Disastrous Outb
2. An Enormous Concrete Reservoir, Computed to Hold 1,000,000 Barrels of

Photo Mr. J. D. Henry

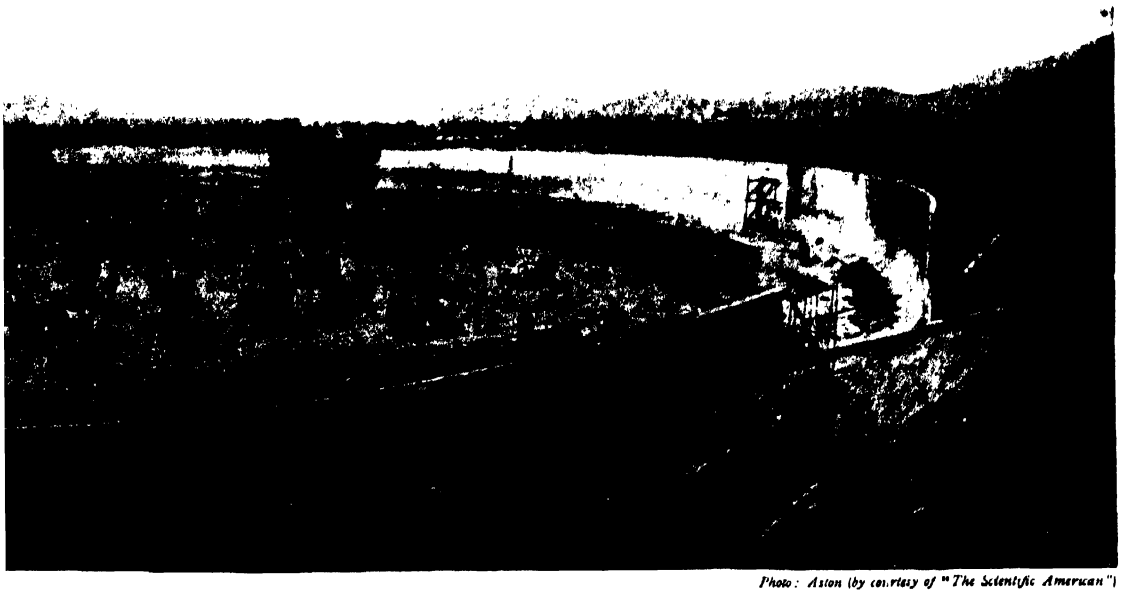


Photo: Aston (by courtesy of "The Scientific American")

at the Spindle Top Field, in Texas
under Construction at Tank Farm, near San Luis Obispo, in California

The totals are counted in barrels, in metric tons, in litres, in poods, in gallons, but we may reduce the figures to common terms, and put the main supplies for last year as follows:—

	gallons.
Algeria	3,000,000
Japan	60,000,000
Roumania	360,000,000
Russia	2,016,000,000
United States ..	9,300,000,000
Java..	1,500,000

A Princely Gift

This, unfortunately, leaves out the important oil-fields of Baluchistan, of Burma, Mexico, Persia, Ecuador, and Venezuela, and several portions of the American continent, whose oil exports are not yet sufficiently regularised to make a computation easy. As the quantity of oil won from the earth becomes greater day by day, it is fairly safe, from the above figures, to assume that the yield for the current year will be 15,000,000,000 gallons. As two or three hundred distinct industries are supplied from mineral oil, it cannot be too liberal an estimate to put the figures for petroleum and its products at £100,000,000 per annum. And this colossal sum is the gift of the Derbyshire village of Riddings, of which millions of people, even in England, have never heard.

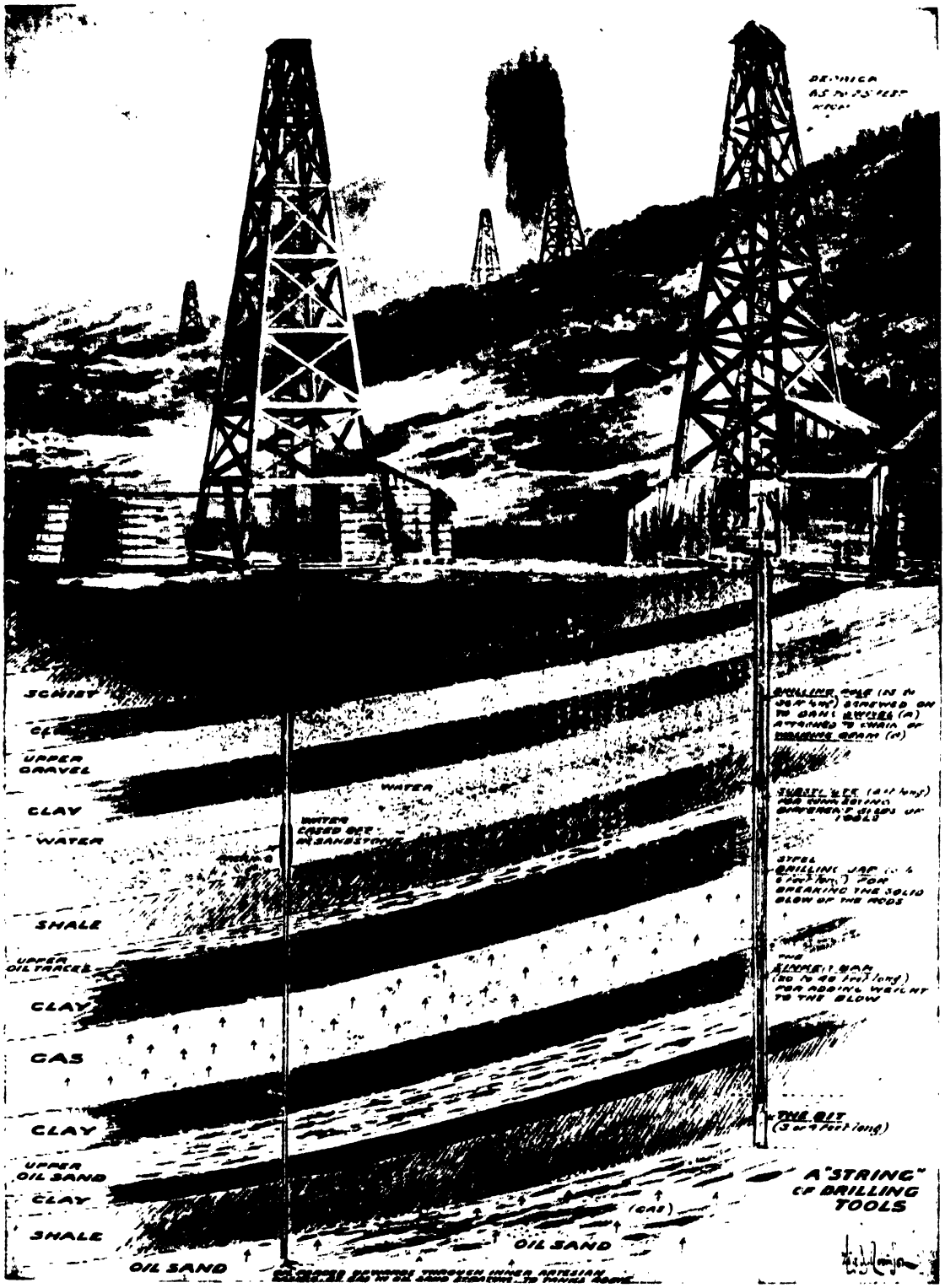
Riddings is a little place three miles from Alfreton, with a population of 6,000, who depend for their livelihood upon the coal-mines and ironworks in the vicinity. In this unimpressive village was cradled the industry which is now world-wide in its ramifications; an industry which has worked the biggest revolution in the world since steam was first harnessed for the service of man; an industry which enables us to soar towards heaven's gate by aeroplane and airship, which enables us to plunge into the depths of ocean safe, so to speak, within the submarine; which has given us the motor-car, that permits us to live next door to everywhere. It tars our roads and scents our linen, it flavours our confections and fertilises our fields, it lights the cottage of the shepherd and drives the sledge across the Antarctic snows; it cleans a greasy motor-coat or pair of gloves, and propels the ship of Amundsen halfway round the world to discover the South Pole. It is all Derbyshire-born!

Petroleum is older than man, and has been used for various purposes since days before the dawn of history, but men only skimmed it from the pools of water into which it had oozed from the earth, or collected it in shallow hollows roughly scooped in the soil. Nobody knew much about it when, in 1847, James Oakes, an ironmaster in a small way, was working coal and iron at Riddings. It was his good fortune to have for a brother-in-law Lyon, the future Lord Playfair.

Playfair was a great practical scientist. He was the man who initiated the late King Edward into chemistry, and made him prove his faith by plunging his naked hand into a cauldron of molten metal. Associated with him at Glasgow University had been a humble carpenter, James Young, the man who prepared Livingstone's way to house-building in Darkest Africa by teaching him the use of tools. Young was employed at the University to repair scientific instruments in the laboratory, and by industry and acumen acquired considerable attainments.

A Stream of Oil

Towards the close of 1847, Oakes, when boring for coal, came upon a stream of oil, and consulted Playfair as to its meaning. Playfair saw at once that it was petroleum, and appreciated its significance as a commercial product. He knew the oil could have no value for his brother-in-law, but it occurred to him that the skilled, industrious Young could profitably turn it to account. As the entire industry of petroleum and its products arises from this little find in a small industrial village in Derbyshire, the letter upon which it was founded



How Oil is "Struck" and Brought to the Surface

(Drawn by W. B. Rowlson)

"Formerly," as the Oil Well Supply Co. explain, "it was a very difficult, tedious and expensive operation to drill a deep well, but now one can be sunk 2,000 feet at a moderate cost, and in a comparatively short time. The modern method is an adaptation of steam power to the method practised for ages in China. Free falling tools, suspended by a cable and worked by steam power, are used, the weight of the tools being so great as to give blows of sufficient force to pierce the hardest rock"

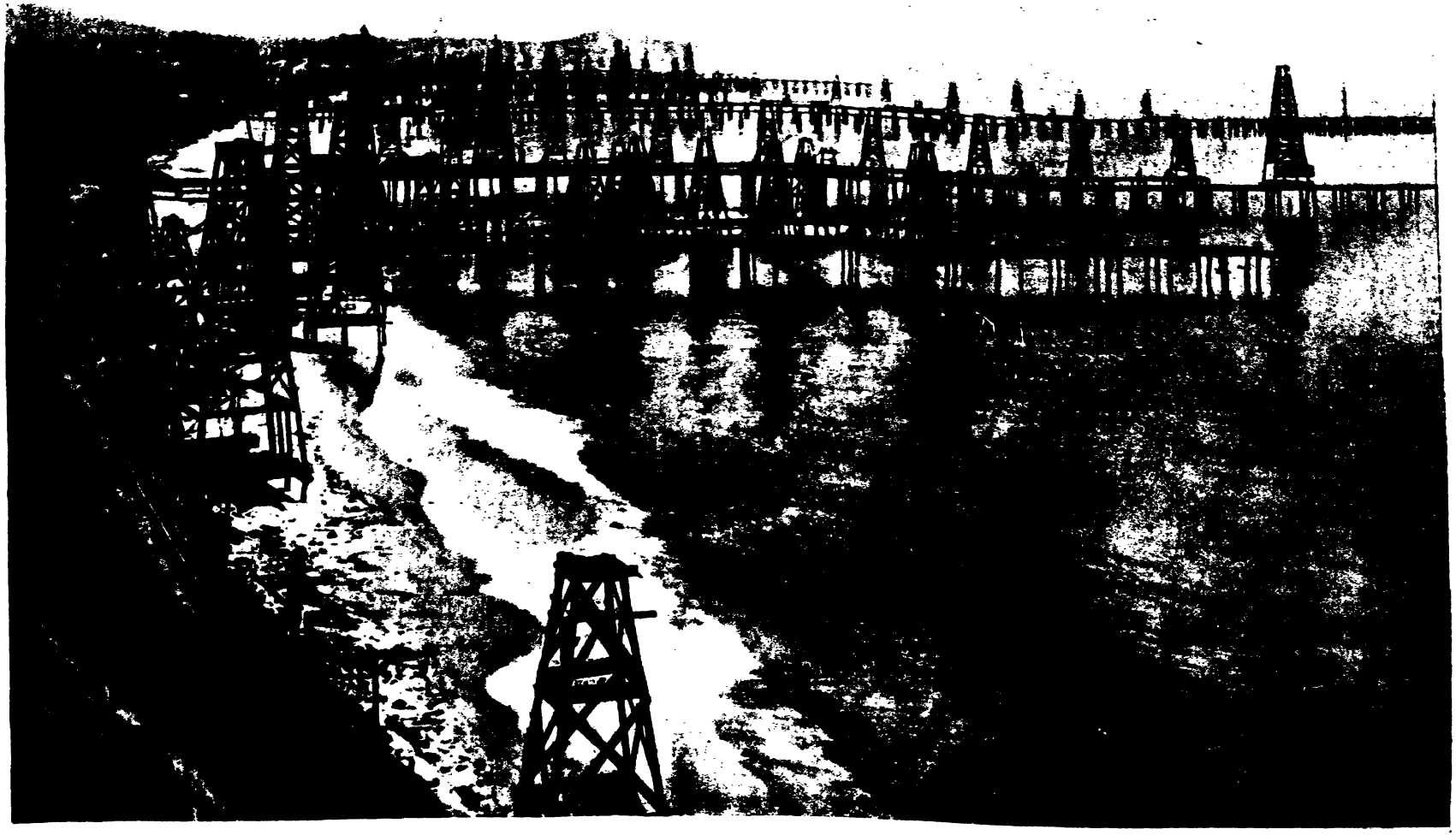


Photo: Underwood & Underwood

Oil Wells Sunk into the Bed of the Sea off the Coast of California

The actual difficulty of mining for oil is not so great on the seashore as through rocky strata, though the sight of the towering derricks set up amidst the waves certainly appeals more to the imagination

may well be read with interest. It is as follows, and oil kings on pilgrimage may care to note the address from which it issued—the house should surely be worthy a commemorative mural tablet :—

26, Castelnau Villas,
Barnes, Surrey.
3rd *December*, 1847.

MY DEAR YOUNG,—You know that mineral naphtha is a rare natural product, no spring of it occurring in this country, all being imported from the Continent or Persia. Lately a spring of this valuable product has been discovered on an estate belonging to my brother-in-law, Mr. Oakes, near Alfreton, Derbyshire. It yields at present about 300 gallons daily. The naphtha is about the consistence of thin treacle, and with one distillation it gives a clear, colourless liquid of brilliant illuminating power. It dissolves caoutchouc easily. My brother intends to set up stills for it immediately ; but, as they are ironmasters, this would be a separate industry, so I have advised them, if possible, to sell the naphtha in the crude state to chemical manufacturers, and thus avoid carrying on an industry foreign to their occupation. Does this possibly come within the province of your works ? If it do, I will send you a gallon for examination. Perhaps you could make a capital thing out of this new industry, and enable my friends to do the same. You are aware that naphtha is now largely used for adding to the illuminating power of gas, and that the tar residue is a valuable product."

Young accepted the offer, and with the help of a friend erected a refinery, and produced, after distilling, a light oil for illumination and a heavy oil for the purpose of lubrication. For the first time England had mineral oil for lighting its lamps in place of whale-oil, and a tender, sympathetic old lady asked : " What'll the whales do now, poor things ? "

Not long after Young's refinery had been started, however, he went with a grave face to Playfair to report that the oil was clouded and turbid. Ruin, he thought, had come upon him. Could the scientist account for the untoward condition ? He could. " The cloudiness is due to a rare substance known as paraffin," was the answer. Playfair comforted his protégé, and asked him to extract some of the residue for him. Young produced enough to make a couple of candles, and with these Playfair lighted his desk at the Royal Institution, for a lecture on " Petroleum and its Products." These candles, the first ever made of paraffin wax, cost a sovereign each to produce. They were the parents of the enormous industry in paraffin-wax candles with which the homes of the poor have ever since been lighted. Similarly, the little stream at Riddings gave rise to the vast petroleum industry, but less directly.

The First Paraffin Wax

The stream produced only 300 gallons a day for two years, then ran dry. As it is found that good petroliferous land yields rather more than 200,000 gallons of oil per acre, we may take it that the cradle of the industry comprised just an acre of land. Quite recently, a second source has been tapped at Newark, in the adjoining county of Nottingham, so, presumably, the field was wider, if intermittent, than was imagined sixty years ago.

A Brilliant Guess

The impending failure of his oil-well compelled Young to cast about for other supplies, and he made a brilliant guess at the origin of the liquid. It was but a guess, and it would be but a guess to-day. No man can say even now from what petroleum is truly derived. Some think that it has been distilled at a low temperature, under high pressure, from coal. Others hold that it arises from vegetation decomposed under pressure, while a still more formidable consensus of opinion has it that every drop of petroleum comes to us from the remains of sea organisms of other epochs. Young's guess was that he could artificially obtain a similar oil by distilling coal. And he was right. When the oil ceased to flow at Riddings, he patented his process in 1850, and, establishing himself at Bathgate, Scotland, began the manufacture of mineral oil from coal. He gave the world a new light,

The Romance of Oil-fields

Photo: The International Press Photo Co.

An Oil Gusher in Full Flow

Cases are on record in which the oil, once tapped has carried destruction everywhere

a new lubricant, a new fertiliser and a new prime mover.

Licences to use his patent were granted to American manufacturers, where, for several years, coal was distilled for the production of petroleum. The process eventually directed attention to the vast natural resources of the land. Young had begun with natural oil and gone on to coal; his imitators, using his patent, had begun by distilling coal. They now turned to the source whence he had first drawn his riches. The petroleum fields of the United States were tapped for commercial purposes; those of Russia, Roumania and Galicia, of Burma and Algeria, Japan and the Dutch East Indies, were afterwards laid under contribution, and to-day practically every feasible portion of the earth's surface is being surveyed and probed for this liquid gold of ten score uses. The method of winning the oil from the earth forms one of the most fascinating chapters in the story of industry.

In the past, prospecting for oil has been a highly speculative venture, with enormous profits for men here and there, but disappointment and disaster for their neighbours. After Young, by his distillation of coal and shale, had taught the world the essential value of mineral oil, and set them to draw it ready-made from the earth, a certain Colonel Drake, in 1859, drilled the first oil-well ever scientifically sunk. From a depth of 70 feet it brought oil to within 10 feet of the surface, and pumping did the rest. The gallant colonel drew out oil worth £160 a day, and, so to speak, set the world on fire. There followed a rush for oil, challenging the rush for gold. We have within the last year or so seen, in the shape of a mad boom on the Stock Exchange, a recrudescence of the mania, which has done as great disservice to the oil industry as the rubber boom has done to planting.

The pioneers, in Pennsylvania and elsewhere in America, had innumerable trials to face before the oil industry assumed

settled proportions. For every man who struck oil, hundreds drew blanks; and for many to whom success came, ruin attended from the inability of the finder to control his treasure. Cases are on record in which the oil, once tapped, has gushed forth in such uncontrollable volume as to sweep away all devices for its retention, to pour unrestrained far and wide, and carry destruction everywhere, to live-stock and crops, so as utterly to beggar the man who established the well. Even to-day the same danger has to be combated on every new field, and, it may be, in successive developments of the same well.

During the Russian revolution of a few years ago, certain wells on a famous oil-field were reported on fire, and panicky shareholders, believing that the flames would extend to the source of the oil and actually burn out the wells, experienced the wildest alarm, and were ready to sell their securities almost at waste-paper prices.

But a man who knew reminded them that only the surface oil derricks and plant could burn; the fire could not penetrate into the wells themselves; you must have oxygen to effect combustion; fire cannot descend an air-tight pipe. And in that timely explanation we get the secret of the construction of an oil-well.

The shaft is not the equivalent of that sunk for the mining of coal or for the raising of water by bucket. The completed oil-well is simply a narrow pipe thrust down to the oil-bearing stratum. It may be a few hundred feet in depth, it may be two or three thousand. The boring is effected by various types of drills, driven by a steam-engine erected at the head of the well. As the boring progresses the drill is periodically withdrawn, and a sand-pump or other implement is introduced to bring up the debris and prepare the way afresh for the drill. As soon as an appreciable depth of shaft has been effected, a stout iron pipe, of from two to three inches' diameter, is inserted, and, as the depth increases,

Photo The Fleet Agency

Spouting Oil-well on Fire

A flaming torch of crude oil 300 feet high near Bakersfield, California

smaller pipes are forced down inside the first, and all carefully united; the narrow shaft is thus encased in iron from the summit to the surface of the oil. Were this precaution neglected, sand and soil and water would speedily choke the shaft and render the miners' efforts nugatory.

Considerable capital and heavy, difficult labour are involved in establishing an oil-well. An English company spent over a million sterling in the Dutch East Indies before they brought a single gallon of oil to England. A shallow well may cost only a few hundred pounds; one of greater depth as much as £1,500—this for the mere sinking of the shaft.

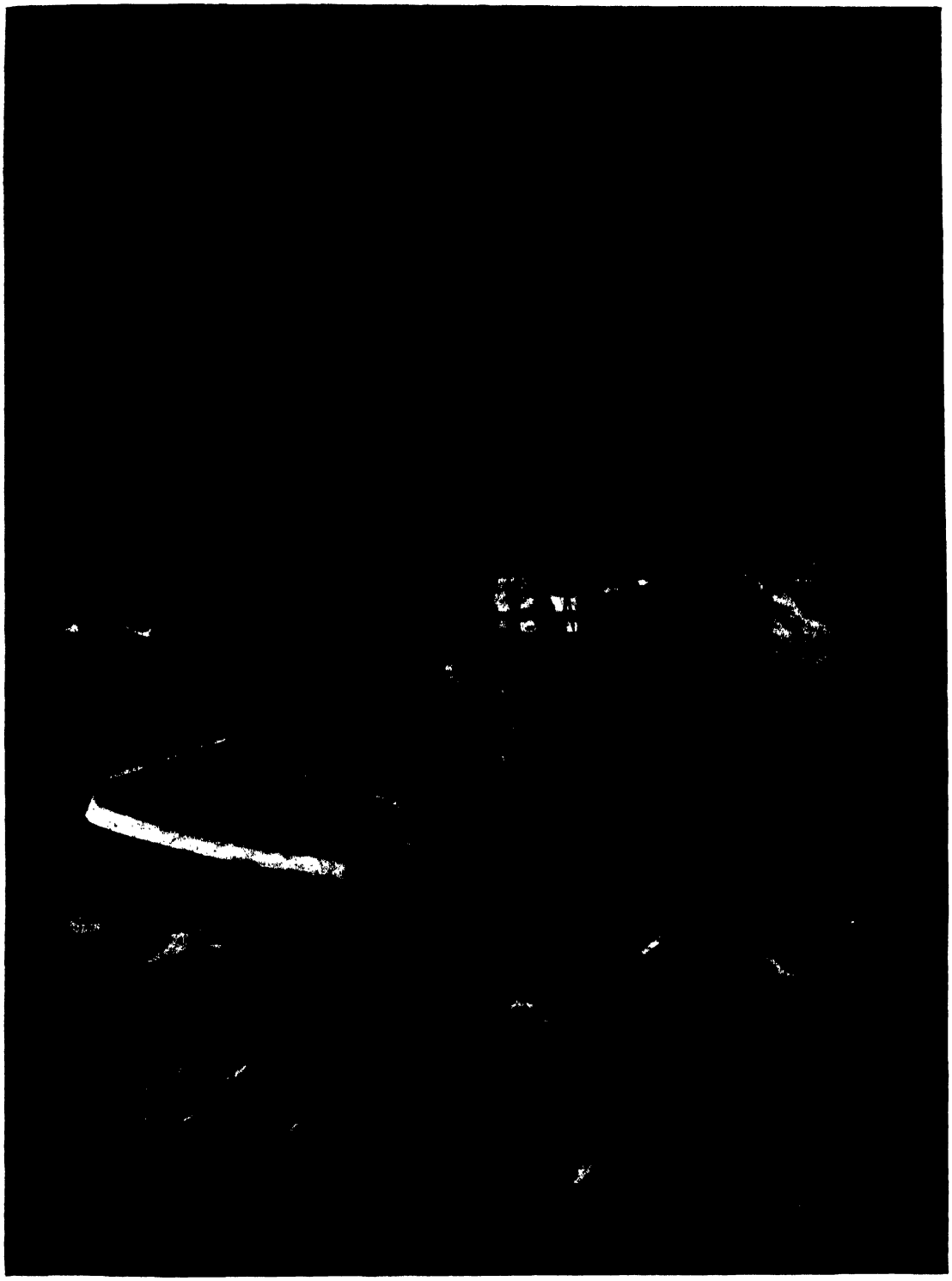
Costly Preliminaries

Once the shaft is sunk, the oil may rise in invincible volume, or it may slowly mount the pipe, or it may refuse to rise at all. In the latter case an explosive is lowered into the shaft, detonated, and the imprisoned oil set free. A sluggish well may need pumping, or some other artificial method. The pump would seem simple enough to be operative in any well. But oil wells have a way of confounding the ordinary engineer. In spite of every care, the oil, when brought to the surface, may prove heavily charged with sand and grit. This is fatal to pumping. If the mechanism escape choking, it is quickly ground to pieces by the scouring sand. In this case recourse may be had to the baling method. An enormously long cylinder, containing a valve opening inward is plunged down the shaft. The oil enters by way of the valve and cannot escape. The baler is then withdrawn to the surface and its contents, of from 200 to 800 gallons of oil, run out into a tank. This baler, primitive as its action appears, can bring up as much as 120,000 gallons of oil in the course of twenty-four hours. A second method, of later date, is to run an endless leathern band down the shaft and, as the returning half comes up saturated with oil, to press it between rollers, which squeeze its contents from it into tanks. Compressed air, too, is laid under contribution. For this purpose two shafts are required. Down one compressed air is forced, so that the aerated oil rises without further ado by the ascending shaft.

Natural gas is always associated in greater or less quantity with petroleum, and this it is which, when present in volume, produces the "gushers," the spouting wells which belch forth their millions of gallons of oil and fling it to the four corners of the compass, forming rivers and lakes and miniature seas in the country round about, in spite of all that the art of the engineer can do to control it. To combat rushes of this kind a sort of hydrant, technically termed a "casing head," is employed. This is screwed to the top of the shaft, and, by the aid of powerful valves, keeps the rush in check, and leads it tamely through a series of pipes to a receiving tank. But even these powerful implements are sometimes blown to atoms by the tremendous rush of the gas-charged oil, and hydrant and fittings are shattered into a thousand fragments before the power of the spouter. It is at times such as these that fire is to be feared. The stream of oil, mounting high into the air, is carried far as spray, while its highly inflammable vapour travels still farther. A spark suffices to cause a conflagration, which—a reeling cyclone of flame and hideous smoke—lights the scene for miles, and menaces the property of an entire oil-field.

A Dangerous Experience

Battle with fire at a petroleum well is as trying and dangerous an experience as the fireman has to contemplate. The intensely inflammable character of the oil, the great area over which danger is diffused, the overwhelming force with which it issues from the shaft—sometimes with a pressure of 500 pounds to the square inch—the imminent danger that the firemen, themselves drenched with the combustible fluid, may be involved in the conflagration,



A Floating Oil Tank, Capable of Carrying 6,000 tons of Crude Oil

(Drawn by N. Sotheby Pitcher)

The drawing shows a curious oil-carrier of the Anglo-American Oil Company, as she appears when being towed in a heavy head sea. This vessel has no motive power of her own, owing to the highly inflammable nature of her cargo of 6,000 tons of crude oil. Should she get adrift, her only means of propulsion would be small trysails set on the hollow steel masts, which are used for discharging the oil, which is pumped out through them. The steamer which tows the oil-carrier is itself oil-driven

form a problem of thousandfold perils. A favourite expedient is to propel along rails a sort of titanic snuffer—a huge metal bell suspended at the summit of a steel crane. This is cautiously worked forward along the metals until the outburst is reached, then lowered upon the flame. If it can be kept in position the fire must be extinguished. But often the force of the escaping blazing oil is too great even for this monster extinguisher. In that case, all other means having failed, there remains but to play upon the fire with converging jets of steam. The sudden expansion of the liberated steam creates a local vacuum, in which no flame can live.

A Titanic Snuffer

Under the best of conditions a fire on an oil-field is a terrible contingency from which every engineer prays to be spared. The flames are not, as a rule, confined to the gusher, but extend to the surrounding lakes of oil. On more than one occasion fire followed the escaping oil to the water, with the result that horrified navigators have seen their craft afloat upon a blazing river. It was but last year that an accident to a petroleum ship set the bay of Naples alight.

Generally speaking, however, the engineers of the wells manage wonderfully well to avoid this worst of perils. Oil-getting is a highly organised science, engaging particularly bright brains, and the man who can pump oil from beneath the sea may be trusted carefully to guard his wares. The actual difficulty of mining for oil is greater in rocky strata than on the seashore, but the sight of the towering derricks set up amidst the waves, like animated beacons striding out to sea, certainly have a greater appeal to the imagination. But every type of engineering scheme comes within the purview of the man out for oil; from the piercing of mountains, of quicksands and submarine strata, to the building of 40,000,000-gallon reservoirs, or the creation of a labyrinthine pipe-delivery system which conveys the refined oil from the source to the port at which it is pumped into tank-steamers that carry it, 10,000 tons to a cargo, from side to side of the world, to be distributed in road-wagons, in cans carted by motor and horsed van, in barrels and tins slung upon camels that pad the hoof across the weary desert, or mules that climb the dizzy mountain barrier. Distribution in itself is one of the supreme feats of organisation by which this world-wide industry is distinguished.

Between the derivation of the oil and its distribution come, of course, the multifarious processes by which it is reduced from a malodorous, viscid treacle, by successive distillations, to kerosene for lamp-oil and cooking fuel; to paraffin for wax and lubricant, whether for the running of ponderous machinery or for the anointing, by means of salve, of the delicate lips of beauty; to petroleum-spirit for the driving of motor-cars and aeroplanes; to heavy fuel for ocean greyhound or submarine, for railway locomotive or tramcar; to asphalte that renders roads dustless and impervious to wet; to the residual products which give us dainty essences and perfumes and anæsthetics. The industry in residual products is, indeed, of equal importance with the sale of the purified oil itself. So much is this the case that great fields, remote from the world's highways, remain undeveloped, simply because these residual products as yet find no near market, albeit the world is clamouring more and more for the indispensable petrol and kerosene. As illustrating the universal application of this Derbyshire-born industry, it is tragically interesting to recall that a single gallon tin of this oil would have sufficed to bring Captain Scott and his heroic comrades back from the fatal wilderness to safety. It was the absence of a tin of petroleum that doomed him and them to a pitiful death.

Multifarious Processes

By J. S. Hudgson

A Blaze in the Oil-field

Under the best of conditions a fire on an oil-field is a terrible contingency, from which every engineer prays to be spared. The flames are not, as a rule, confined to the gusher. On more than one occasion fire has followed the escaping oil to the water, and horrified navigators have found themselves and their craft afloat upon a blazing river

The Amazing Phenomenon of the Sea described on page 437

In Nature's Laboratory

The Exasperating Doldrums—Nature's Alchemy—
Mysterious and Unexplained Phosphorescent Rays

By FRANK T. BULLEN

Author of "The Cruise of the 'Cachalot'"

IN that stretch of ocean between the varying southern limit of the north-east Trade winds and the equally variable northern limit of the south-east Trades there is a great oblong stretch of sea that was known in old sailing-ship days as the "Doldrums." Why it was thus called I have not the least idea, yet somehow, from use probably, it seems the appropriate and significant word to apply to what all sailors remember as being one of the most unpleasant parts of the watery globe. For here, in this vast, landless space, the wind, released from the operation of those wonderful laws which had compelled its hardly deviating adherence to certain quarters of the compass, and its steady persistence in strength, played all manner of fantastic tricks. It must however, be stated, in strict justice, that among these tricks anything like gale violence had no place.

Indeed, as far as force was concerned, the wind in these regions very seldom compelled the taking in of the lightest sail. It varied, in direction, through every point of the compass in half an hour, and, in strength, from a flat calm to a fresh breeze in the same time. Not only was this the case laterally, but vertically the same

vagaries obtained, for it was no unusual experience to have the lower sails entirely becalmed while the upper ones felt quite a breeze; sometimes, even, there was a breeze in the courses and top-sails from, let us say, the north, while the top-gallant-sails and royals had one from the south-west. And so both ship and crew grew utterly bewildered and sullen, although, of course, it was unthinkable to let her alone—the yards must be continually trimmed to every flaw if ever the ship was to get out of the baffling area at all.

But this was only a part of the sailor's trouble in those exasperating regions. In addition to his incessant and apparently fruitless toil at the braces, he had to contend with rain of such incessant incidence and quantity that it was farcical to attempt the wearing of oilskins. Not that it mattered much, since the weather was bound to be warm; but one's hands and feet grew soft and flabby from continual soaking, and made the never-ending hauling a purgatorial penance. The ropes, swollen by the wet, stuck in the blocks, needing as much exertion to heave on them as to swing the yards, while the softness of the hands made all ropes feel like burning wire, especially on first turning to after a watch below. In a little while one got more used to the pain, and it became bearable, but it was hard at the best of times.

As a compensation for these undoubted drawbacks, the sailor had here the opportunity of witnessing Nature at work on her usual colossal scale. Here the whole atmosphere is surcharged with electricity, and continually, from the vast masses of cloud that make the heavens appear as if hung with black velvet, lambent, varicoloured flames will play without any sound of thunder, as if the electrical sea must overflow and become visible, although without any violent manifestations of energy. And I am led to believe, though I have no certain data to lean upon, that this great collection of electrical energy was responsible for that wonderful alchemy of Nature that man was here permitted to view in highest operation—and in those leisurely days he had much time to observe it—far too much indeed for his wishes.

Photograph copyright by William Hope Hodgson

A Stupendous Lightning Flash

From the vast masses of cloud that make the heavens appear as if hung with black velvet, lambent, varicoloured flames play as if the electrical sea must overflow

Here, as nowhere else in the world, may be seen waterspouts, concerning the origin of which wonders so many conflicting theories have been advanced. To see one in operation is to conceive once and for all an admiration for the grand simplicity and effectiveness of Nature that is all too apt to carry with it contempt for the puny efforts of man.

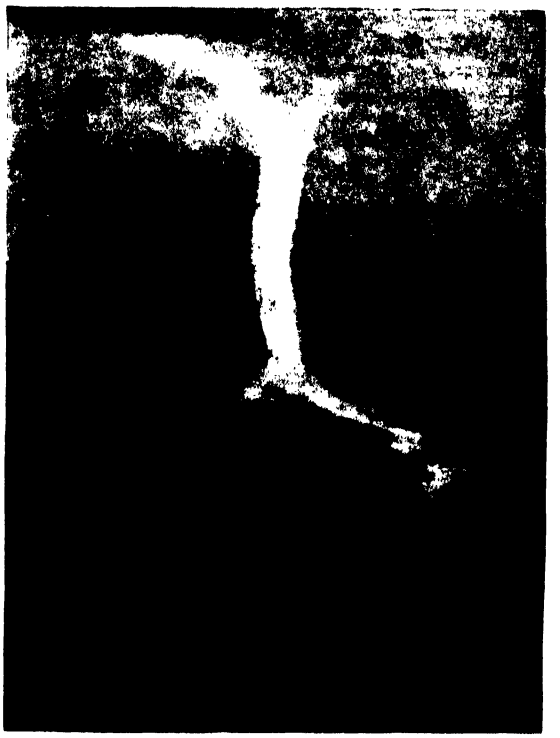
Upon the shining surface of the sea, which looks like undulating shot silk, there will appear a little mound or hillock of water, just like an inversion of the vortex

in a glass of water stirred by a spoon. There is no visible cause for this gyration of the sea at this particular spot, nor does it appear to be very rapid; but overhead, in a sullen-looking cloud, may be noticed at the same time an agitation apparently sympathetic with the whirling mound in the water, and presently it will be observed that the cloud is sagging downward at one point. That point will be almost exactly over the spot in the water that is so curiously elevated. Then will be seen emerging from the bulge in the cloud a point, composed of cloud, and wavering about as if in a breeze. This point lengthens rather rapidly, taking on, as it does so, a fantastic likeness to an elephant's trunk waving about in search of something to lay hold of. Presently it reaches the whirling mound in the water, which one could almost fancy reaches up to meet it and immediately a junction is effected—communication is established between sea and cloud. Should the observer be near enough, he may both hear and see the process going on, while ever the gloom overhead deepens. At last the connecting tube begins to dwindle, and this goes on until it becomes a mere thread, continuity ceases—for there is no sudden rupture—and the swaying, wavering trunk is gradually absorbed into its source again.

As the cause of this phenomenon has been fully discussed on pages 69 *et seq.*, we will not go into that here. Let it suffice to state the fact.

A less known wonder of the sea, the cause of which has aroused much speculation, since *The Sphere* published a sea-captain's account of the phenomenon, is illustrated on page 435. This took the form of a strange display of light on the sea's surface. When seen by Captain Gabe, of the Danish East Asiatic Company's steamer, *Bintang*, the vessel, according to *The Sphere*, "was passing through the Strait of Malacca, in June, 1909. The light waves took the form of long curved arms issuing from a centre, around which the whole system appeared to rotate. The mysterious rays seemed to temporarily light up the phosphorescence of the sea."

The same journal published another account in 1912, this time from the captain of the Wilson liner *Ariosto*, according to whom the weird spectacle was seen "at 7.30 p.m. on February 17th, 1912, in latitude 23·37 N., longitude 67·2 E. As we approached the spectacle it had the appearance of breakers on a low beach, but when we got into it at first it looked like flashes of light (not bright) coming from all directions in quick time. After some few minutes of this the flashes assumed a lengthened shape, following quickly one after the other from the north, and these continued some minutes, steadily veering east and south and south-west into north-west."



Photograph copyright by William Hope

A Large Waterspout

To see one in operation is to conceive once and for all an admiration for the grand simplicity of Nature

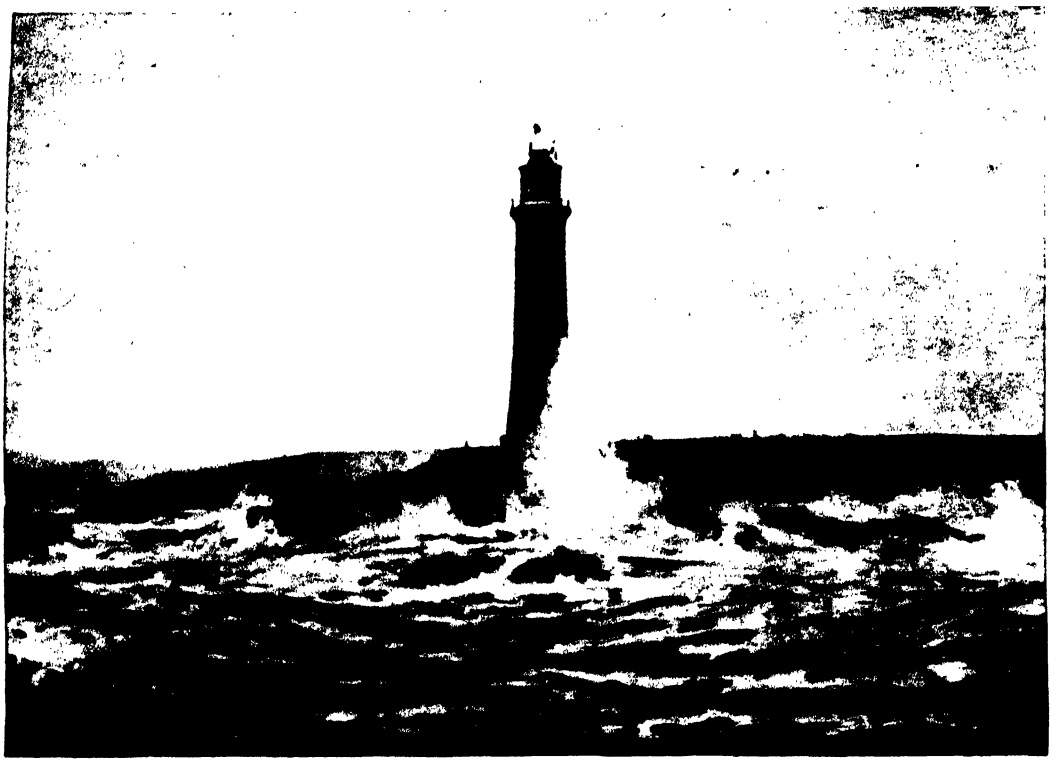


Photo: Clarke and Hyde

Longships Lighthouse, near Penzance

The Story of Lighthouses

How the Heroic Sea-Builders Battle with the Storm for the Lives of Mariners

By H. J. SHEPSTONE

EVER since man began to navigate the waters he has endeavoured to light them at night. This he accomplishes to-day by the erection of beacons or towers upon the shore and rocks, from the summit of which a beam of light is automatically flashed over the ocean, and also by means of lightships and illuminated buoys. There are now no less than 259 lighthouses, and 64 lightships around the coasts of the United Kingdom, or a light station to every sixteen miles of coast line. How necessary these lights are to guide and warn the mariner is obvious by the returns of wrecks. In a given year we find as many as 3,000 vessels are damaged or lost on the coasts and in the seas of the United Kingdom.

The father of the modern lighthouse was undoubtedly the ancient Pharos of Alexandria, in Egypt, one of the seven wonders of the world. It was built by Ptolemy Philadelphus (283–247 B.C.), on a small island at the entrance to the harbour, connected by a causeway with the mainland. The Pharos cost 800 talents; if these were silver talents—as most likely they were—that would be equal to £170,000, the largest sum ever expended upon a single lighthouse. The structure had a base of some 400 feet, and towered 450 feet above sea-level. As

the whole was built of white marble, the edifice must have been at once elegant and impressive. At the summit fires were kept burning to direct the mariner through the tortuous entrance of the bay. It is recorded by some of the ancients that the flame of the Pharos could be discerned 100 miles at sea. This, of course, is an exaggeration, as the most up-to-date light of modern times, with all the latest inventions for increasing its intensity, is only visible thirty miles out. It is doubtful if the smoky gleams of the ancient Pharos were seen twenty or twenty-five miles on a clear night.

Church, Palace, and Beacon

The Romans built many lighthouses, and it is said that several exceeded in splendour and magnificence the famous Pharos, but not one of them remains. The earliest example extant of a lighthouse is the famous Tower of Cordouan, France, which dates from 805 A.D. but has been rebuilt on several occasions. The present edifice, which was commenced by M. Louis de Foix, in 1584, is certainly one of the most remarkable edifices in the world. This lighthouse (originally 180, now 207 feet in height), is beacon, church, and royal residence in one, many of the French kings having occupied it.

Until the time of John Smeaton, who invented the dovetailed stone tower, lighthouses, with a few exceptions, were built of wood. It was Smeaton's success in placing a stone edifice on the dreaded Eddystone Rocks, in the eighteenth century, which gave an impetus to lighthouse building.

Since that time the sea-builder, as the man who builds these lighthouses is called, has been busy erecting lights on dangerous islands and pinnacles in all parts of the globe. Before Smeaton built his stone lighthouse on the Eddystone, these rocks had been twice marked with a light. The first structure, built by Winstanley, was overwhelmed one night in a storm, and the builder and his keepers were carried to their deaths; the second, the work of John Rudyard, was burnt to the water's edge, and one of the keepers lost his life through swallowing the melted lead, which fell from the roof and entered his open mouth as he gazed upward. Both these lighthouses, of course, were of wood, the first being ornamented with fantastic balconies and bay windows.

Smeaton's first tower of solid stone braved the elements on the Eddystone for 123 years, when it was dismantled and re-erected on the Hoe at Plymouth, and another tower put up in its place on an adjoining reef. The reason for the removal of the lighthouse was that the rock on which it stood had been worn away by the action of the sea. Long before this occurred, however, it had been demonstrated that the stone tower was the best device for equipping a wave-washed rock with a light. Stone towers sprang into existence on dreary rocks around our coasts and also in America.

The next to be erected, which taxed the pluck and endurance of the sea-builders, was Robert Stevenson's Bell Rock Lighthouse on the famous Inchcape Reef, off the coast of Scotland. It was one long, terrible battle with the angry sea. The securing of the foundations, naturally the most hazardous part of the whole undertaking, was exceedingly difficult. It is recorded that the men worked with desperation. Only two could remain on the rock at a time, but they stuck there with the tenacity of leeches, the cold water of the North Sea bearing down every few minutes and whipping entirely over them.

The First Stone

In describing the progress of the work, Mr. Stevenson tells with quaint humour how the drenched workmen were cheered by a sailor on board the workship, who played sweetly on a German flute. Iron rods were fastened into the reef to hold the courses of the tower. When the first stone was at last swung out on the tipsy crane,

the sea-builders, ragged and chilled, and worn with the awful struggle, clung to the iron rods and cheered madly, like soldiers just over the crest of an enemy's fort. Over and over again the men were absolutely driven from the rock. When the tower began to appear well above the sea, terrible storms would arise and swamp the works. On several occasions blocks weighing as much as two tons were ruthlessly torn out of their places and swept into the sea, despite dove-tailed joints and Portland cement and mortar. In the end, the sea-builder proved victorious, as he always does; but it cost four years' labour, and an expenditure of £60,000 before the light-house stood complete.

Photo Chancellor, Dublin

Placing the Last Stone in Position on Fastnet Rock Lighthouse

Then came the Skerryvore, situated on a storm-swept reef in the open Atlantic, twelve miles from the Island of Tyree, on the west coast of Scotland. This is interesting in that it is the highest lighthouse around the British Isles, towering very nearly 140 feet above sea-level, 40 feet higher than the Bell Rock light, and nearly double the height of the original stone edifice erected on the Eddystone. Operations were commenced in the summer of 1838, but the tower was not completed till six years later, at a cost of £86,000.

The first thing the sea-builders did was to erect a barrack on the bare rock. The framework was put up in the course of a season, but in a great gale which occurred one night, in the November following, it was entirely destroyed, nothing but a few broken and twisted iron stanchions remaining to point out its site. Thus did one night obliterate all traces of a season's toil, and blast the hopes which the workmen had fondly cherished of a suitable dwelling on the rock, and a refuge from the miseries of sea-sickness which experience had taught many of them to dread. A second and successful attempt was made to erect another house of the same description, strengthened by a few additional iron ties, and placed on a part of the rock which it was hoped might possibly be less exposed to the breach of the heaviest waves than the site of the first barrack. This second house braved the storms.

"Perched forty feet above the wave-beaten rock, in this singular abode," says Mr. Alan Stevenson, its builder, "with a goodly company of thirty men, I spent many a weary day and night—at those times when the sea prevented anyone going down to the rock—anxiously looking for supplies from the shore, and earnestly longing for a change of weather favourable for prosecuting the work. For miles around nothing could be seen but white, foaming

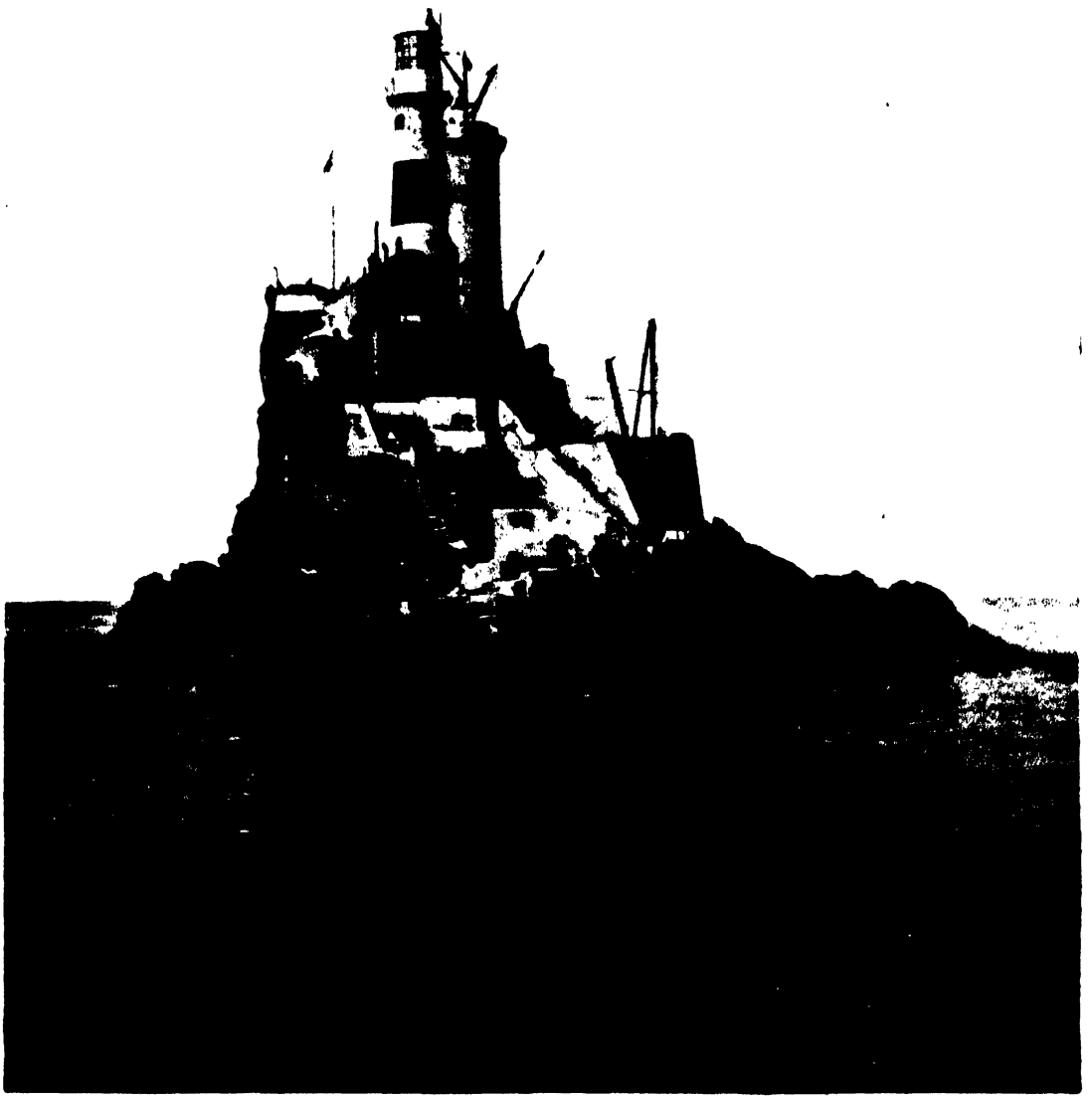
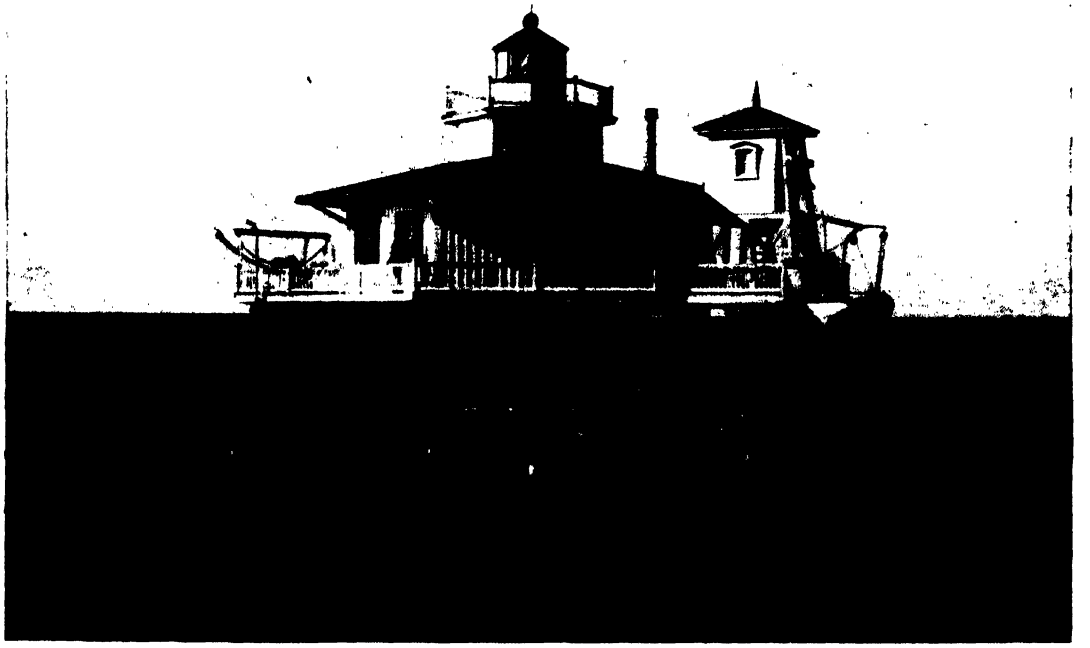


Photo Chancellor, Dublin

Fastnet Rock Lighthouse, Ireland

This is the last light seen by the great liners on their passage across the Atlantic. It is exposed to the full fury of the Atlantic, and the new tower took nearly six years to build

breakers, and nothing heard but howling winds and lashing waves. At such seasons much of our time was spent in bed, for there alone we had effectual shelter from the winds and the spray which searched every cranny in the walls of the barrack. Our slumbers, too, were at times fearfully interrupted by the sudden pouring of the sea over the roof, the rocking of the house on its pillars, and the spurting of water through the seams of the doors and windows—symptoms which, to one suddenly aroused from sound sleep, recalled the appalling fate of the former barrack, which had been engulfed in the foam not twenty yards from our dwelling, and for a moment seemed to summon us to a similar fate."



The York Spit Lighthouse, U.S.A.

Like other American lighthouses this is built on entirely novel principles. A favourite method is to carry a light and the keepers' quarters on iron piles driven deeply into the bed of the ocean, as shown here

The story of the Bishop Rock light, standing on a bare rock which rises sheer out of the sea off the Scilly Isles, is another stirring record of the indomitable perseverance and heroic behaviour of the sea-builder. On one occasion, during the erection of the tower, an iron column, weighing three tons and secured by a heavy chain attached to eye-bolts let into the solid granite, was torn away from its fastenings. A blacksmith's anvil, weighing 1½ cwt., was actually washed from a hole 3 feet 6 inches deep, and 2 feet in diameter, wherein it had been deposited for safety!

When Captain Alexander, the noted American lighthouse-builder, undertook to erect a stone tower on Minot's Ledge Rock, off Boston Harbour, for £60,000, he looked forward to reaping a rich reward for his labours. But, though experienced in the difficulties of his task, when it was finished the gallant sea-builder found himself out of pocket. On his first visit to the reef, it was so slippery with sea moss, and the waves dashed over it so fiercely, that he

could not maintain his footing. Part of the ledge was always covered with water, and the remainder, even at low tide, was never bare more than three or four hours at a time.

On his return to the shore, he sent a crew of men to the rock to scrape it clear of weeds and cut level steps on which one could maintain a firm footing. They worked with desperate energy. When great waves came rolling in from the sea, the foreman shouted, and they all fell on their faces, clinging together and holding their breath until the rock was bare again. Sometimes, when a storm blew up suddenly, and the boats dare not approach near enough to effect a landing, the boatswain was accustomed to throw out a line, which one of the workmen would seize and make fast to his waist ere plunging into the sea. Then the sailors would pull him in like a great clumsy cod. Working in constant danger of their lives, and continually drenched and suffering from the smarting of salt-water sores, the brave sea-builders were able to cut only four or five little holes during the whole of the first season.

In the second year the workmen succeeded in building an iron platform twenty feet above low water. Ropes were stretched between the piles on which it rested, and when the waves were high the men clung to them to escape being washed into the sea. The next winter a big coastwise barque, driven in by a storm, swept away the platform and crushed the face of the rock, ruining two years' hard work in a single night. In the third year the workmen succeeded in laying four foundation stones, and from this point the work progressed fairly satisfactorily. Still, it was exciting. In five years' time the light was finished, "rising sheer out of the sea," as Longfellow described it, "like a huge cannon mouth upward."

Even more terrible difficulties and dangers were encountered in building the Tillamook Lighthouse off the coast of Oregon. Tillamook is a small, abrupt, rock formation, one mile from the mainland. Its sides are so precipitous, so inhospitable, that even in calm weather landing is extremely dangerous, and during the initial attempt to put a working party on the rock the foreman lost his life. The first thing

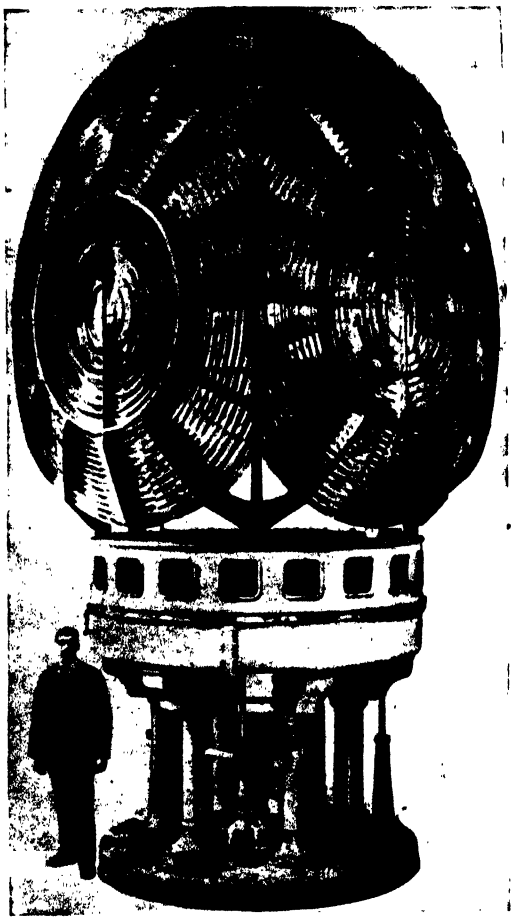


Photo by permission of Mess.

The Lenses that Flash the Light

The Hyper-Radial Apparatus, 1,330 mm. (52.3

the men had to do after they had effected a landing was to drive away a particularly vicious herd of sea-lions. The sea-builders then erected a shelter made of iron and wood, and bolted to the rock. One night a tornado drove the waves entirely over the rock, crushing in the tent in which the men slept, and washing away most of their

provisions, and nearly all their tools, clothing, and equipment.

For days at a time, in the coldest weather of a northern winter, they were compelled to lie clinging to the slippery rock, drenched with icy water, covered with swiftly-succeeding storms of snow and sleet, and cut by the sharp sea winds. During all this time they had not sufficient means of warming themselves, practically no fresh water to drink, and nothing to eat but hard tack and bacon soaked in sea-water. Few Arctic explorers ever had to suffer the perils and privations to which these lighthouse builders were subjected. And yet they lived to build a great lighthouse on the summit of the rock. An idea of the strength of the waves at this spot may be gathered from the fact that only two winters ago a boulder weighing 148 lbs. was lifted bodily by the waves and sent crashing down through the roof of the tower, which stands 182 feet above high-water level!

It has been said of the lighthouses of the United States that no two are alike; down among the Florida reefs, in particular, there are wonderful structures, built in the sea on what is termed the screw-pile method. This consists in carrying a light and the keepers' quarters on iron piles driven deeply into the bed of the ocean. Some of these piles extend to a depth of ten feet into the living coral rocks. The method of erecting them is to build a temporary platform from which to conduct the operations, with steam tugs standing by to take off the workers when the weather turns black. Exciting rescues often take place in bad weather.

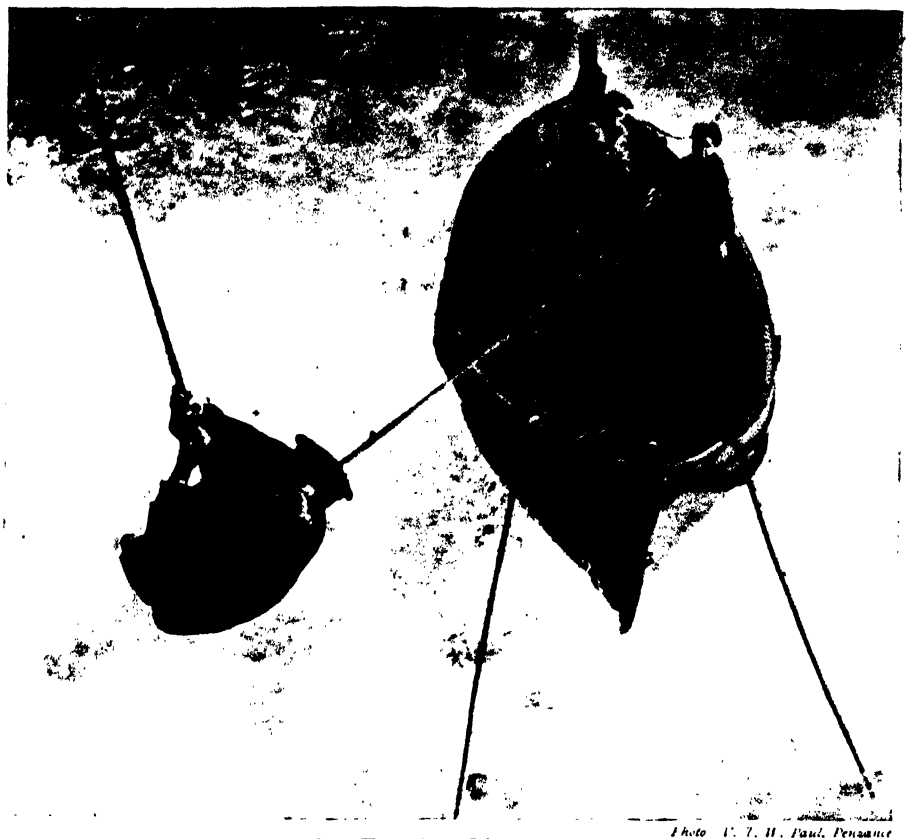


Photo W. T. H. Paul, Penzance

An Exciting Moment

An amazing photograph taken from the Eddystone Lighthouse showing the relief man ascending to the tower in heavy weather

Reptile Jack Tars

The Real Sea-Serpent and Its Way in the World of Waters —Creatures of the Land which have Taken to the Deep

By N. F. WATSON

IT is an amazing thing that every unsophisticated person devoutly believes in the sea-serpent, which does not exist, but knows nothing of sea-snakes with which tropical waters teem. The sea-serpent is popularly described as a leviathan, half an ocean long, with mountainous neck clad with a sea-forest of mane, and supporting a giant head with phosphorescent moons for eyes; a pelagic demon which, meeting a full-masted ship, raises its cloud-piercing head and browses upon the men perched in the topmost rigging. That is the sea-serpent of legend, ancient and modern. Further, it is humbug.

But, let it be added, there was a sea-serpent when reptile life was at its zenith.

The True Sea-Serpent

There was a genuine, very large, and shocking sea-serpent, over 100 feet in length and diabolically ample of girth. It was a member of the great Mosaurus group of reptiles, which, as the titanic ichthyosaurs fell into senile decay, became the tyrants of the world.

It is very strange that stories of the sea-serpent should be revived century after century, for no man has ever been even on nodding terms with one of the order. The true sea-serpents ruled for their epoch, lorded it in the waters, and came ashore on all four limbs further to gratify the voracious appetite, which their terrible teeth, set in skulls 4 feet long, prove them to have had. They died out, millions and millions of years ago, and we find their grossly gigantic fossil skeletons in chalk where the seas once ran. We cannot wholly account for their disappearance, but we are to believe that the rise of the still mightier uncles and aunts of the first toothed whales was responsible in the main for the riddance. But it is certain that there lives to-day no sea-serpent whose remote ancestors were kings of the Cretaceon seas. Sea-serpents are as dead as the mastodon, which some naturalists, dreaming in their arm-chairs, like to believe may still tramp through the twilight gloom of the sunless land round about the Behring Straits. The white walls of Old England have grown up from what was once animate life since the last sea-serpent ate its valedictory supper, yet men talk of sea-serpents as the Maoris used to talk of the giant moa, a bird which their ancestors had really known; as savages talk of dragons which, in the time before man, once had actual existence, in form not wholly unlike the pictures created in the frightened mind of the medicine man of the present-day wilds.

But we hear nothing of the real sea-serpent from those who believe in the mythical example. It is a true snake, and is the deadliest enemy of other forms of life that dwell in the waters. The bite of the cobra is practically immediate death to a warm-blooded animal, but the bite of the sea-snake is fifty times as deadly! It effects instant paralysis of the nerve centres of man or animal in whom the warm blood courses; it stops a big fish dead and turns it upside down in the water when a spear-thrust would

A Deadly Enemy

leave the same fish to pursue its way, and, without manifest discomfort, peacefully to repair the ravages of the intruding iron. How came these multitudinous snakes into the water, and whence is their incredibly lethal venom derived?

The Struggle for Existence

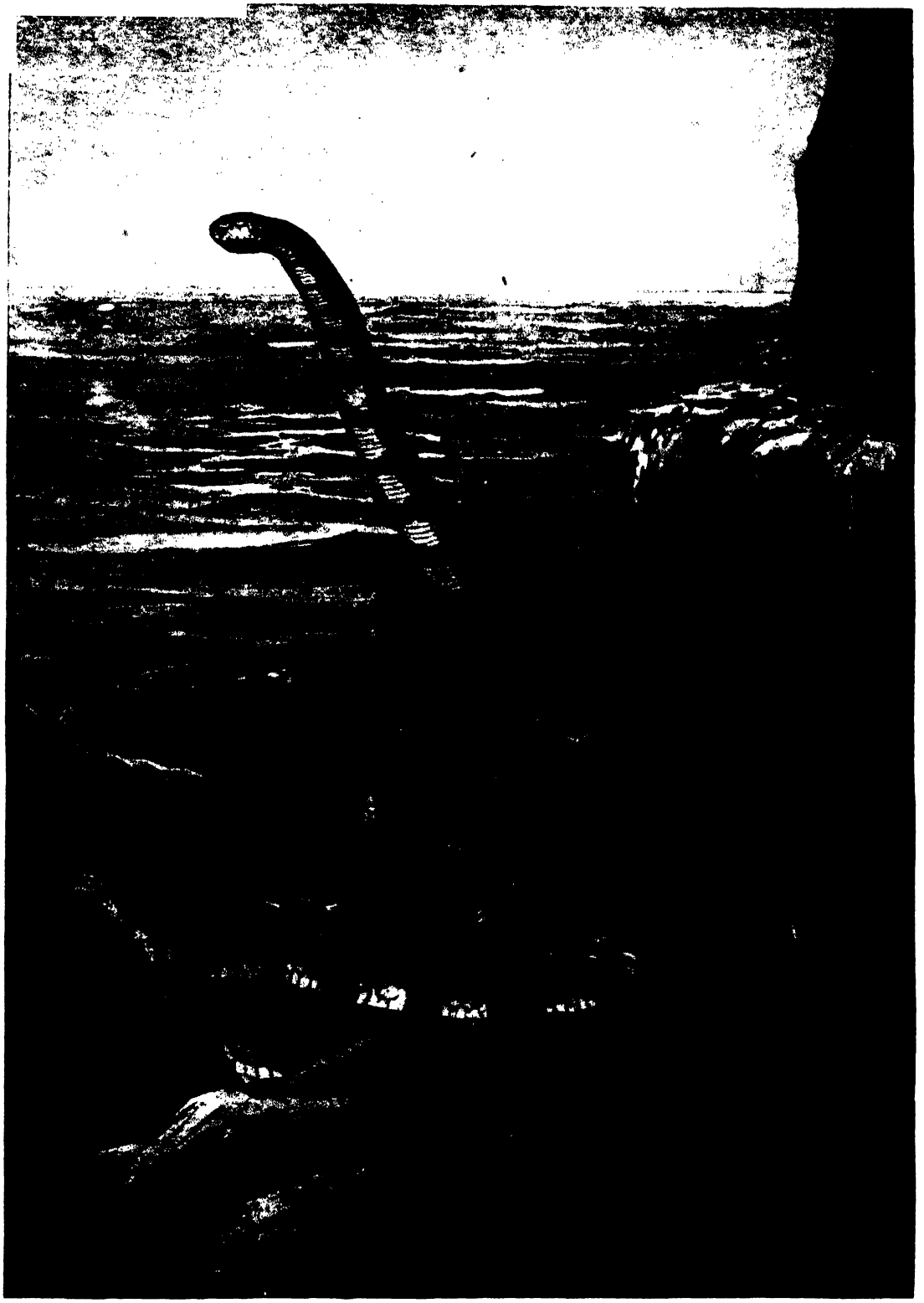
In the struggle for existence, reptiles changed their habits in the long ago. Some converted their fore-limbs into wings and became birds; some turned turtle under a colossal cuirass of bony mail; some shed their limbs and wriggled in the dust as serpents dire and guileful. When this was happening, or at a later date, when serpent legs had been sacrificed in favour of scutes or scales, by means of which the reptile pulls itself along the ground, there came an exodus from the great snake kingdom.

The front-fanged colubrine snakes sent a reconnoitring party, as we may suppose, from the land, back to the sea, whence all life had come. There was not food enough upon the land for all; perhaps, too, enemies had become inconveniently numerous and pressing. The colubrines developed a tribe of mariners, which swam out to sea and fed on the fat of the waters, and returned to their lairs at nights. We may be fairly certain as to the correctness of our reconstruction, for the same sort of thing is going on to-day before our eyes. There is in Sumatra a broad-tailed species of sea-snake which probably poses among its landlubber kindred as one which is "something in the city." For this snake goes far out to sea for meals and returns to dry land to lodge and multiply. The change here from terrestrial to marine existence is not completed.

In the same way the ancient mariners of the snake tribe dwelt longer and longer over their voyages, until the time came when some of them never returned. They stayed in the sea for good. But a great change had taken place in the structure and economy of the snake before this revolution could be effected. Already possessed of deadly venom, it must have found its liquid battery ineffective against fish and other forms of prey. The blood of a mammal gallops, and swiftly distributes the venom of death throughout the frame; the blood of fish and other marine creatures is cold and sluggish, creeps as a chilly stream slowly through the vital nerve centres. A fish struck by the serpent's fangs from which the deadly fluid is emitted, would so slowly feel the effects of the poison that it would swim far away before the wound could prove mortal; in which case the snake would have bitten in vain. So, in order to live, the snake had to become more deadly to other forms of life. The virulence of its poison was enhanced, its killing power magnified again and again, until to-day there is no poison in the animal constitution so frightful as that which lurks in its bulging sacs.

A Modified Outline

Meanwhile, also, the lithe and elongated Jack Tar from snakedom found it expedient to modify his outline. The snake upon land has scales attached to the inferior extremities of each pair of ribs, and with these it grips any inequality on ground or tree, and pulls itself forward, as the centipede, without embarrassment or miscalculation, pulls itself forward by its many legs. Place the lustiest of snakes upon glass, and he cannot progress. The ordinary land-snake is in like case in the water. True, many of them can swim, but that is only a pleasure matter; swimming is not an art developed essentially for utilitarian purposes in the scheme of terrestrial serpent locomotion. The sea-snake rebuilt himself, as it were. He shed his pulling scales; he altered the outline of his body. He took on the eel-like form, with tail laterally flattened, and so modelled his extremity into one of the best of oars, with which to row himself onward to the doom of any living thing within reach of his frightful fangs. And, avoiding the example of the land-snake, he ceased to render



Sea-Snakes, Male and Female, with Young

(Drawn by E. H. Fitchew)

A female of the species shown here (*Platurus fasciatus*) was found coiled up amongst wave-washed rocks, with twenty junior snakes, her sons and daughters, enveloped by her folds, each of the infant death-traps being already 2 feet in length

himself sick and sad by a complete sloughing of the skin at once: he learned to shed it piecemeal, so as always to be fit and fighting.

If we have no sea-serpent of the romantic mythical type, we have at least fifty distinct species of the sea-serpent of fact. But they are contained within small compass—six feet or so covers the entire length. The colour scheme is various, but wonderfully adapted to environment. Generally speaking, the mackerel stripes protect the back from observation, while the underside is light as in the case of fishes. Some, however, have gone to the vanity books for patterns, and have put on gaudy colourings harmonising with the tropical seascapes in which they dwell. But all have this feature in common, that they are, as a great sub-family of reptiles, the most vilely deadly of all known forms of animal life.

Gaudy Colourings

They swarm in the coastal waters of the Indian Ocean; and in the Bay of Bengal appear periodically in such hosts as to resemble assemblages of giant eels. But the natives do not mistake them. The crocodile is feared and worshipped with distant reverence, but the sea-snake is avoided by the men of the coast as fire is avoided by a burnt child. With every precaution, the sea-snake every now and then drives his fangs home in human flesh. The result is inevitably and swiftly fatal. The venom of many snakes coursing through the circulatory system causes the blood to clot, and so to kill the victim. But the venom of the deadly sea-snake has a different power; it acts instantly upon the nervous system, causing violent, immediate paralysis and death. This seems to be the case with every species of sea-snake, whether it strike in the warm waters of the Bay of Bengal or in the tropical waters of the Pacific—from the Persian Gulf to Northern Australia; from the western shores of Africa to the distant coasts of tropical America; from Japan and Manchuria in the north, to New Zealand in the south. Over this vast range of waters the sea-snake is found, yet those who believe only in the fabulous sea-serpent of Olaus Magnus never hear of it.

Everywhere the effect of the sea-snake's bite is the same. As the fangs enter the flesh, the venom is forced by a channel through the tooth into the wound, and the nervous system of the victim is that instant paralysed. This is a wonderful, a diabolically successful device. There is no waiting for the poison to be carried by the sluggish blood of a big fish to the heart or respiratory system. Nature allows the sea-snake only one bite, but that bite settles the matter: the nervous system is shattered at once. Death travels by nerve telegraphy, not by the slow post of the circulatory system of the blood.

The sea has its other Jack Tars from the reptile world; the turtles beloved of aldermen, and the turtles contemned of aldermen, such as that uneatable giant, 18½ cwt. of him, which recently reached London via a Lowestoft trawler, a leathery turtle which cheers but does not feed the Nature-lover. But the warrior tars that our own valiant sailormen fear are those of which we have been thinking.

Though they have taken finally and completely to the water, the sea-snakes have not put off all their terrestrial habits. They are still air-breathers, not gilled water-breathers as the young of salamanders are. They retain the old serpentine method of breathing, but they have copied the sharks and whales—fish and mammal—in a wonderful way in that, instead of laying eggs, which would meet the ready jaws of voracious fish in the sunny waters, they retain their eggs until the young are hatched. They produce their young alive. And to show that even the vilest death-dealing serpent has its maternal instincts unblunted, let it be added that these unloved demons of the

Maternal Instincts

deep have been found carefully tending their young. One of the species, *Platurus fasciatus*, was discovered coiled up amongst wave-washed rocks, with twenty junior snakes, her sons and daughters, enveloped by her folds, each of the infant death-traps being already 2 feet in length.

The "Sea-serpents" of Prehistoric Times

In prehistoric times there undoubtedly did exist in the *Plesiosaurus victor* monsters resembling the fabled sea-serpent of current legends

Marvellous as are the adaptations which make these reptile sea-dogs what they are, the modifications have the defects of their qualities. The typical sea-snake, though a true air-breather, cannot long survive withdrawal from the water, but dies if pitched ashore from the net of the trembling fisherman who has been unfortunate enough to catch it. The Sumatran examples already cited, which are found a day's march inland, have not yet specialised, or degenerated, so far as this, but are amphibious in the unscientific sense of the word. With the rest of the dreaded tribe it is not so. Cast ashore they share the fate of the whale, the shark, or H.M.S. *Dreadnought*. But there are enough in the sea to keep the family going. They have a wide domain and an illimitable food supply.

The Greatest Libraries of Past and Present

Libraries of Fifty Centuries Ago—Storehouses Wherein are Treasured the World's Literary Masterpieces

By E. A. BAKER, M.A., D.Lit.
Author of "History in Fiction"

A VISITOR to the British Museum, though he may look in vain for examples of the contents of far more modern libraries, can see numerous examples of what constituted the book stock of libraries in Assyria and Babylonia. Till Layard began his researches in the forties of last century—though there were misty legends of vast libraries belonging to the Pharaohs—nothing was positively known about the books and libraries of remote antiquity. Layard unearthed the remains of a building supposed to have been the royal library of Assurbanipal, in the seventh century B.C.; and in our national museum are exhibited some twenty thousand inscribed tablets, which formed the pages of thousands of baked clay books, covered with cuneiform writing—treatises on astronomy, magic, law, dogma, historical annals, state records, and the like, and even a catalogue of the books in chief demand, which enables us to study the literary tastes of the reading public two and a half millenniums ago.

Photo: Alinari, Rome

The Pope's Private Library in the Vatican

Later excavations on the site of Nippur, a city of Babylonia, take us back far earlier, for an inscription relating to the year 3750 B.C. has been found there. Here were exposed the remains of a smaller library of books in the same durable material, like that of Assurbanipal systematically classified and well organised for the use of students.

In comparison with these, the famous libraries of Alexandria and Pergamum, of Greece and imperial Rome, seem to belong to quite a modern era, and continual allusions to them in classical literature have put them on familiar ground. The two great libraries of Alexandria were the first in importance in the ancient world. They were founded by the Ptolemies in the third

century B.C., the earlier one in the fashionable quarter called the Brucheion, and probably within the precincts of the royal palace, the other in connection with the temple of Serapis. As a work of sumptuous architecture the latter building was considered to be unexcelled save by the Roman capitol. Both libraries, like that of their rival at Pergamum, founded by King Eumenes II., were developed by their royal founders with the energy of an American multi-millionaire. The Alexandrian palace library is said to have contained eventually 490,000 volumes or rolls of papyrus; Pergamum boasted a stock of 200,000 volumes. The Ptolemies thought nothing of seizing a vessel containing books, confiscating the originals, and dismissing the captain with copies instead. Ptolemy Euergetes is said to have supplied Athens with corn in time of famine in return for the official copies of the great Greek dramatists. Alexandria was famous for its librarians, who were the most eminent scholars of their time. Zenodotus produced the first collated text of Homer; Callimachus was a great critic and grammarian, and also a poet; another librarian was Aristarchus, whose name has been a synonym for austere criticism in all ages. Eumenes adopted absolutely piratical methods of extending his library. He seized private collections having any value, and tried to seduce one of the Alexandrian librarians from the service of his master, who took the drastic measure of putting the unhappy official into prison until he had made up his mind to remain loyal. When Alexandria, in order to cripple its rival's activities in the duplication of books, put an embargo on the export of papyrus, the king of Pergamum invented parchment, or *charta pergamena*, skins prepared and smoothed for writing on both sides. We used to read that the Caliph Omar destroyed the great Alexandrian library at the Mohammedan invasion of Egypt; in reality both libraries had perished centuries before. Little remains of the libraries of Greece, but we can easily picture what any of the twenty-eight public libraries of Rome must have looked like, housed in stately buildings with pillared porticoes, the walls inside lined with presses or cases holding the books, which were rolls

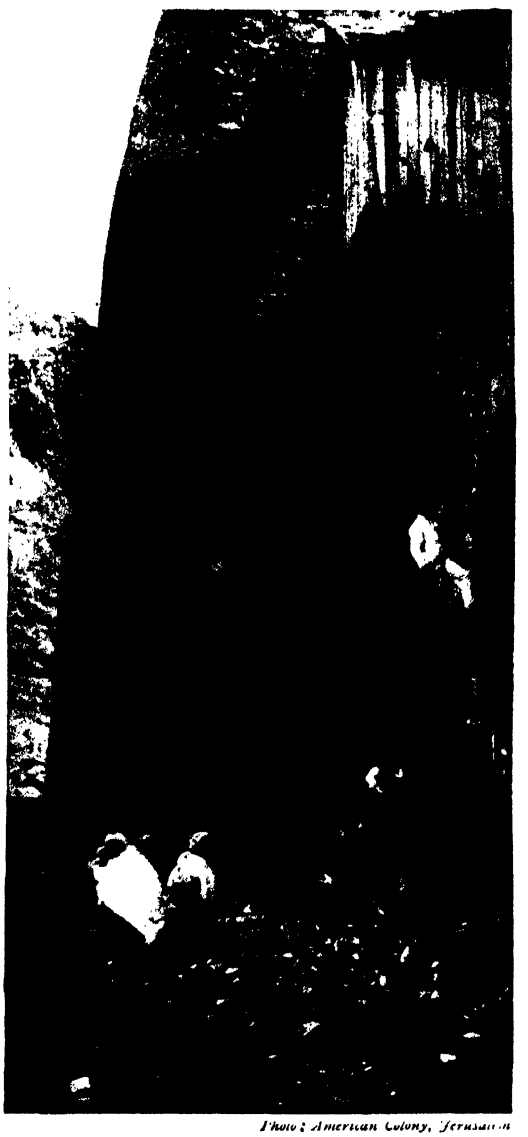
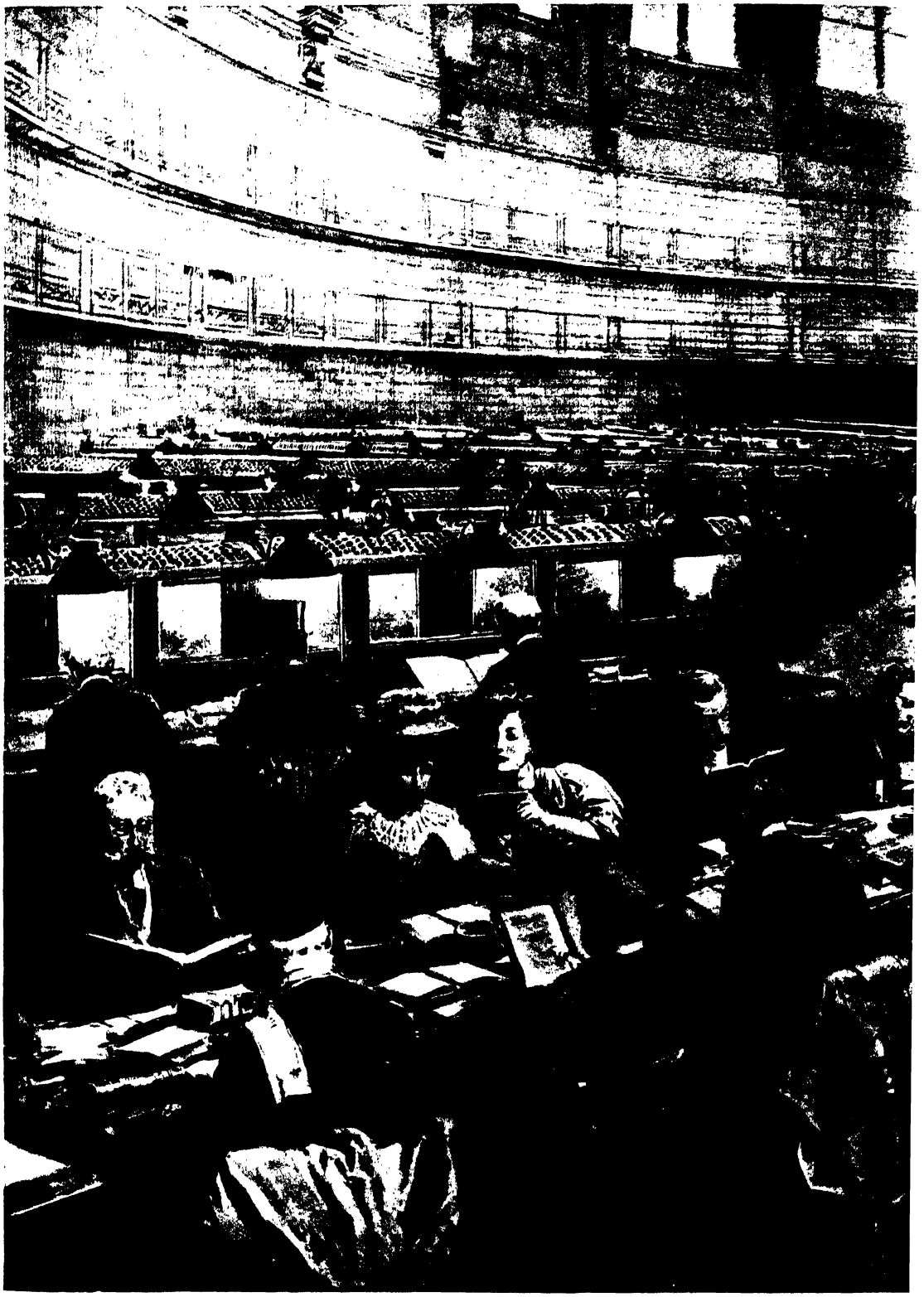


Photo: American Colony, Jerusalem

Entering the Monastery of St. Catherine, Mount Sinai

In its library was discovered the famous Codex Sinaiticus, a most valuable New Testament MS., dating, it is believed, from the 4th century. The Codex is thought to be one of the fifty copies of the Scriptures executed in the year A.D. 331



THE READING ROOM OF THE GREATEST LIBRA

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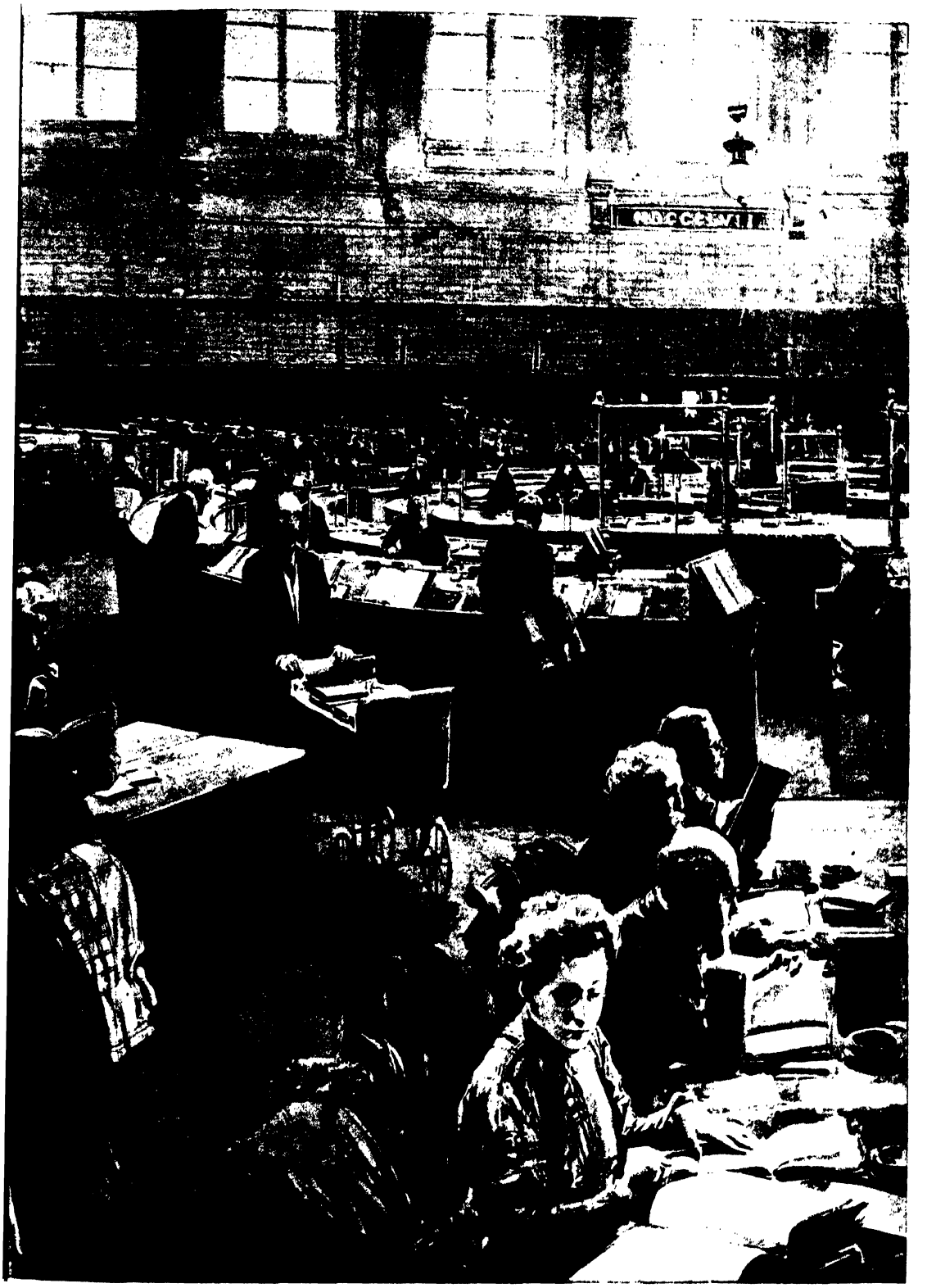
The British Museum library is truly a "library of libraries," constantly absorbing vast and wealthy colle
come to the reading-room from both hemispheres to consult unique documents; it



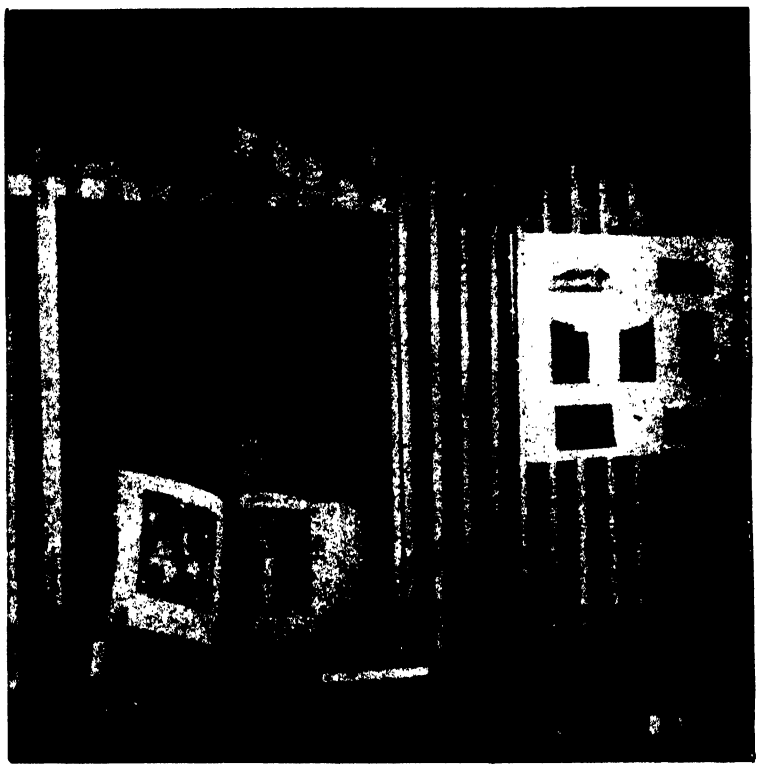
IN THE WORLD, IN THE BRITISH MUSEUM, LONDON

F. Matania)

of books such as the Old Royal Library, the King's Library (of 65,250 volumes), the Grenville Library, etc. Scholars of the world for the making of books. And to its millions of volumes another 40,000 are added annually

of parchment or papyrus, the ends duly labelled with the titles of the works they contained.

Numerous examples are extant of the monastic libraries which formed the link between the libraries of antiquity and those of modern times. In the Bibliothèque Nationale at Paris, often described as the largest library in the world, we have one with a history connecting the Middle Ages with to-day. It was founded by King John of France, who was captured by the Black Prince at Crecy, was shifted to Blois, to Fontainebleau, and back again to Paris, was largely expanded by the addition of libraries forfeited during the Revolution, received an increased grant from Napoleon, and has been energetically administered ever since. It now contains nearly three million printed books, 250,000 maps, a million prints, and upwards of 110,000 manuscripts, those of Oriental works being especially numerous. It is pointed out, however, by Mr. R. A. Rye, in his useful handbook to the libraries of London, that the claim of the Bibliothèque Nationale to pre-eminence cannot be sustained. If the same system of counting were adopted, the contents of the British Museum Library, officially estimated at between two and three million volumes, would probably reach from four to five millions. This is gratifying to patriotic feeling; but we must not hastily conclude that London is better off in library resources than any other city, for in proportion to population, the same authority tells us, Berlin, with its various libraries, has a supply of two volumes per head, whilst London can give only a little over one per head; Dresden provides three, and Paris four volumes per head of population.



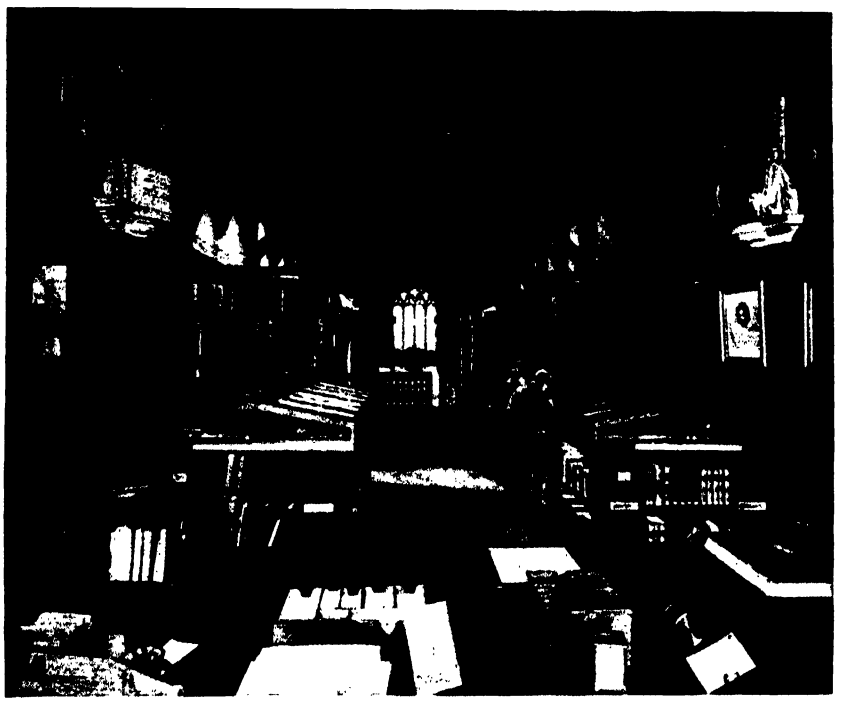
The Famous Library in the Monastery of St. Catherine, Mount Sinai

Nevertheless, the British Museum certainly contains the most wonderful library in the world. It is truly a library of libraries, for though it began only as far back as 1753, it has grown by enormous strides, absorbing vast and wealthy collections of books, such as the Old Royal Library, the King's Library, a magnificent treasury containing 65,250 volumes besides pamphlets, the Grenville Library, and many large special collections, not to mention the multifarious stores of books in papyrus and inscribed tablets from the ancient libraries already alluded to. The British Museum is one of the workshops of the world for the makers of books. Scholars

come there from both hemispheres to consult unique documents; and, though admission is granted only to those engaged in serious research, the great circular reading-room is always thronged with readers busily employed. The catalogue, which is a bare alphabetical list of the books, gives one the best means of realising the stupendous extent of the collection. It consists of 1,500 folio volumes, each as big as one can handle with any facility, which are arranged on both sides of a series of cases describing an arc 90 yards in length.

Behind the walls enclosing the vast reading-room are the piles of rooms and galleries containing the main stock of books, and the rooms where a small army of librarians and attendants are at work. During the principal librarianship of Sir E. A. Bond the sliding press was introduced, by which it is possible to store several books in the cubic space formerly occupied by one. The presses or bookcases are suspended from girders on which they slide, so that when a book is obtained the whole case is slid back behind the others. The book stack thus becomes a solid mass of books, multiplying the storage space of a library enormously. Even so, however, the Museum is unable to house all its possessions on the premises, and the immense stock of provincial newspapers is kept in a special repository at Hendon. With four other libraries, the British Museum enjoys the right to receive a copy of every publication issued in this country, and its annual increase averages something like forty thousand volumes.

In some respects the Bodleian Library at Oxford is still more interesting. For one thing it is much older, being founded in 1445, and re-established by Sir John Bodley at the end of the sixteenth century in a building which has the right atmosphere of antiquity and scholarship. Among its stock of 800,000 printed books are priceless treasures from the early presses, and its 41,000 manuscripts form one of the richest collections in existence. The Cambridge University Library comes next in importance among English libraries outside London. One of the richest, however, in accumulations of rare and choice editions is quite a new library, that bearing the name of John Rylands, at Manchester.

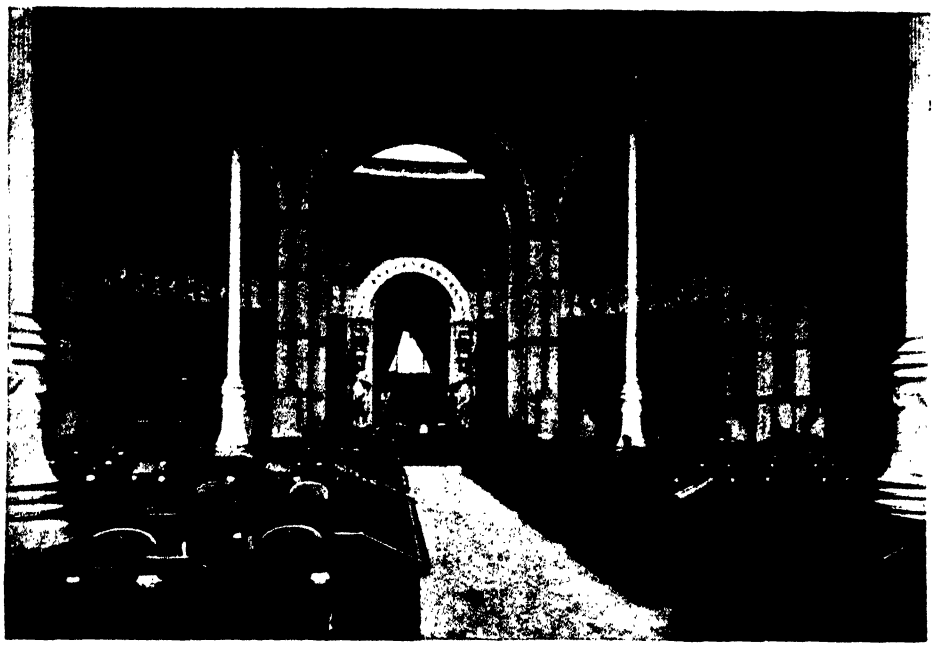


The Bodleian, Oxford

Founded in 1445: among its stock of 800,000 printed books are priceless treasures from the early presses: its 41,000 manuscripts form one of the richest collections in existence

The renowned Althorp collection of incunabula, or early printed books, was acquired from the late Earl Spencer, and formed the nucleus of this fortunate library, which is established in a beautiful building—one of the masterpieces of modern Gothic—has a wealthy endowment, and is steadily amassing further treasures.

It was only by a fluke that the Althorp Library did not go to America, where so many bibliographical rarities, as well as so many famous pictures and other works of art, are now in private hands.



The Great Reading Room at the Bibliothèque Nationale, Paris
It contains nearly 3,000,000 printed books, 250,000 maps, 1,000,000 prints, and upwards of 110,000 manuscripts

The public libraries of the United States are far in advance of ours, the stinted support granted to British libraries having no place in America. Thus, although we have had a longer start, it is quite possible that America will eventually distance Europe in the size and richness of its collections, as it has already distanced us in the liberality and efficiency of its system of library administration. The largest free circulating library in the world is the Boston Public Library, which contains over a million books, and in the year 1907 had a circulating issue of 1,529,111 volumes. The building containing it is the finest of its kind in America, with the one exception to be described next; and, apart from its purely architectural nobility, is famous for the series of mural paintings by Puvis de Chavannes which adorn the interior. Americans build for the future, and make ample accommodation for vigorous growth. At the back of stately façades and spacious reading-rooms the book stack is the great structural foundation of the American library, built of steel girders, fireproof, and solid enough to resist earthquakes and tornadoes. In the Library of Congress at Washington, the national library of the United States, we have a model of the most elaborate mechanical equipment and the most efficient methods of administration, and also the finest building anywhere dedicated to the purposes of a library. The building cost seven million dollars, and is planned to contain 4,000,000 books, the area covered being 8½ acres.

From a Painting by Sir H. H. Johnston

The Crimson-breasted Barbets

The barbets are insect-eating tree birds, of delicate or brilliant coloration, distributed over the tropical regions of both hemispheres, though more abundant in the Old World. Perhaps the most beautiful of their forms is the one here illustrated, a native of Equatorial Africa from the Cameroons to Uganda

Photo lent to Sir H. H. Johnston by the New York Zoological Society

An Albino Indian Peacock

Fine Plumage—II

Concerning Some of the Most Gorgeously Arrayed among the 14,000 or 15,000 Species of Known Birds

By SIR H. H. JOHNSTON, G.C.M.G., K.C.B.

THE paradise birds scarcely need to be mentioned here in connection with the subject of fine-plumaged birds, as they are such familiar instances. Perhaps in some examples of this group Nature has reached the climax of bird beauty, both in fantastic outline and in colour. The colours, indeed, of the group of crow-like birds, which includes the closely related bower birds and paradise birds of New Guinea and Australia, have a range of tint more varied and subtle than perhaps any to be seen, except amongst the parrots, who may rival but who cannot surpass them in this respect. For in the *Paradiseidæ* we have, besides a development of blue which is to be seen nowhere else—smalt-blue, cobalt, ultramarine, blue-purple, pinkish-azure, and turquoise—tufts, plumes, or crests of peach colour; mantles of glowing topaz, maize, or apricot-orange; gorgets of beryl-green, pure emerald, vivid crimson, cream colour and purple; underwear of a straw-yellow, or sulphur; and head caps or face patches of metallic silver and gold.

The group of parrots: what a range of colour display it can offer to the eye! Besides the crude red, blue and yellow of the larger macaws, there are the delicate pinks and greys of cockatoos and Australian parrakeets. Two or three of the latter offer combined tints of pale delicacy—primrose-yellow, blush-pink, bluish-grey. Some of the true parrots are scarlet-crimson; some of the lories and parrakeets have vivid purple or blue plumage. The only really dowdy parrots are the rusty black Vasa parrots of Madagascar and the Comoro Islands, and certain brown-green ground parrots of New Zealand and South Australia.

The trogons are another group of gorgeous birds, very few of their own species being other than vividly coloured in the male, though the female is sometimes of

From a reconstruction in the American Museum of Natural History

American Egrets in a South Florida Cypress Forest

Perhaps the most beautiful of the herons are the pure white egrets, which are persecuted by the plumage hunters for the sake of the spray-like plumes which grow on their backs in the breeding season

Fine Plumage—II

dowdy tints. There are a few species of trogon (crimson, green, purple, and checkered black and white) in Africa and Southern Asia, and in far-back times trogons existed in France before man emerged from apehood. But the great extension of trogon evolution in our own age has arisen in tropical America. Here dwells—if it has not been completely extinguished by the plumage hunters during the last ten years—the most amazing of all trogons, that which was deemed a sacred bird by the civilised Amerindian people of Central America—the quetzal (*Pharomacrus mocinno*). The male of this species (in body not much larger than a thrush) has tail plumes some eighteen inches long, and its plumage (developed into crests and elongated wing and tail coverts), is brilliant green — ranging from emerald to turquoise, with crimson-lake breast and under-parts, black and white quills.

The trogons are a distinct group of that great cohort of birds known as *Coraciiformes* or Roller-like birds, a group which is distantly related to the Passerine or singing-birds, and which includes within its limits the rollers, owls, goat-suckers, swifts, humming-birds, kingfishers, hornbills, hoopoes, barbets, toucans, and woodpeckers. What visions of beauty and wonder and fantastic appearance does not this series of divisions call up to one's imagination? —the woodpeckers with their bold black, white, crimson or orange, or red and green, yellow and green, orange and brown, chestnut, black, and cream coloration, and their bills like cones of ivory, jade or jasper; the owls with their fluffy plumage of delicate contrasts and varied patterns, though never including any tints but cream, yellow, chestnut, grey, black, and white, but with their great eyes showing a glowing iris of topaz, ruby, or sulphur-yellow; the rollers themselves (which give their name to this loosely connected group), like their distant allies the kingfishers and bee-eaters, exhibiting a range of azure-blue, blue-green, mauve-chestnut, and ultramarine in prevailing tints. The hornbills, like the owls, are devoid of gorgeous colours, but are sufficiently striking in their colour contrasts all the same: chestnut, cream-yellow, purple or greenish black, and pure white. Unlike the owls, however, the hornbills indulge in patches of bright colour on the bare skin or the wattles of face and neck, and their beaks are so brightly painted with red and yellow or black and yellow that they literally *look* as if they were painted. The ground hoopoes have big, showy crests, and are black and fawn, cream, chestnut, white and grey; but tree hoopoes have iridescent tints of emerald and ultramarine,

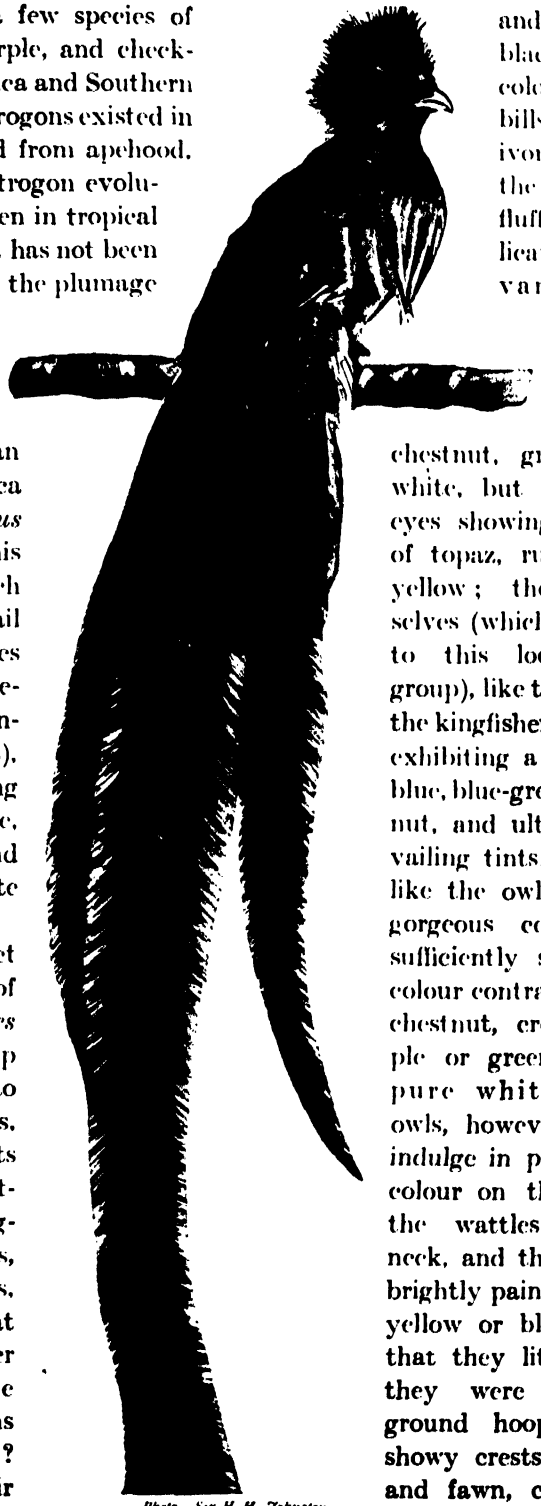


Photo Sir H. H. Johnston

The Quetzal

The wonderful Trogon of Central America

red-brown, and green-black, often contrasting prettily with grey-white gorgets and coral-red beaks and feet. The most noteworthy and the most vividly tinted of the kingfishers come from New Guinea and the Malay Archipelago, and have their tail-feathers lengthened into racket-shaped plumes. The bee-eaters add to the kingfishers' colours one tint that is lacking in that group—pure crimson. This is the colour of the throat, chest, and underparts of the body in some of the most lovely examples of that exquisite family—a family which should be rigidly protected throughout the world because of its incessant pursuit and destruction of noxious insects. As a matter of fact, throughout the British Empire many agencies are at work rapidly destroying the bee-eaters for the plumage trade.

Kingfishers and Bee-eaters

Amongst the Passerine birds, besides the *Paradiseidæ* already mentioned, we have as examples of lovely or eccentric coloration the beautiful little banana quits or sugar-birds of the West Indies (*Coerebidæ*); the lovely finch-like tanagers of America; the sunbirds of the Old World — more gorgeous in their positive and their iridescent tints than the humming-birds (for which they are often mistaken); the weaver birds of Africa and Asia, many of which in their smaller forms are decked in blazing colours, or in the tiny wax-bill type are still more charming in pale blue, grey-pink and brown. The widow birds (a member of this group) develop disproportionately long, curved tail-feathers in the costume of the male at the breeding season. The finches in the crossbills of Europe and in the cardinal birds of North America, or the rose finches of Asia and America, run to gorgeous tints of red in their plumage, while the *Cyanospiza* of tropical America is vivid in a combination of blue, red, and yellow-green.

There are the exquisitely-tinted, long-tailed jays and magpies in tropical Asia (with blue predominating in their colour scheme); and from the point of view of form, wing-spread, and beak, the great black and white ravens of Africa are striking birds. Examples of beauty not due to bright colours but to delicate adornments are to be met with in the celebrated parson bird or tui (*Prosthemadera*) of New Zealand and the lyre birds of Australia. Some of the African and Indian shrikes are most vivid in coloration—crimson, black, white, cobalt-blue; the tits and the fly-catchers offer numerous examples either of dainty combinations of colours or adornments of very long tail-feathers, face-plumes, or crests.

For beauty of plumage the whole group of the pigeons takes very high rank, though it is only in the great crowned pigeons of New Guinea that there is any elaborate crest. In the family of the fruit-eating pigeons the most exquisite tints are developed and conjoined—lilac, grass-green, crimson, pink, greenish-black, creamy-yellow, copper-red, rich purple, and sulphur-yellow. One species may be mainly orange; another indigo-blue, white, and vermilion. A member of the genus *Ptilopus* has a plumage ranging in tint from rosy-lilac to bright green, peacock-blue, yellow, dull green, silver-grey, and orange, while another is mainly purple, apricot colour, rich green and deep blue.

Amongst the storks the great Marabou is to conventional ideas hideous with its bare and seemingly scabby head and neck, yet it is a magnificent object when in flight, being perhaps the biggest of flying birds. The tantalus and the saddle-billed storks are actually beautiful in plumage. The former is snowy-white with jet-black wings, bare coral-red face and legs and bright yellow bill. But the plain black and white of its plumage is charmingly relieved by the rose-purple tips of the feathers on the wing-coverts and tertiaries. The saddle-billed stork is a magnificent creature in appear-

1. British Kingfisher 2. Hoopoe. 3. Panyptila Swift, with its extraordinary pendulous nest, constructed by the bird out of fibre and saliva. 4. Prevost's Humming Bird. 5 The Kagu, of New Caledonia

ance. The head and neck, the back, tail, wing-coverts and tertiaries are glossy-black, shot with iridescent reflections of green, blue and purple. The shoulders, underparts and quills are pure white. The legs are purplish-red, and the long beak is crimson-scarlet barred with black and decorated on the culmen by a plate or saddle of bright yellow. Amongst the herons of white heron not necessarily closely related, all of which go by the name of egret, greater or lesser. There is a reason, not purely of sentiment, against the destruction of these beautiful birds for so futile a reason as their possessing plumes of decorative value; and this lies in the fact that these egrets, together with the smaller species of heron, live mainly,

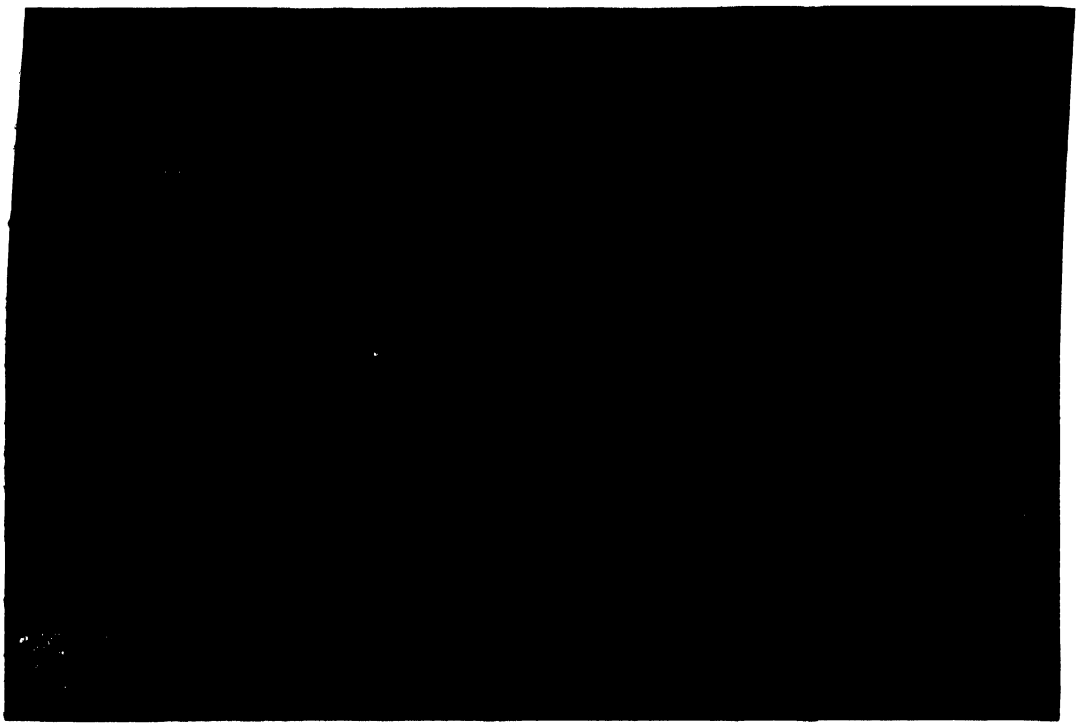


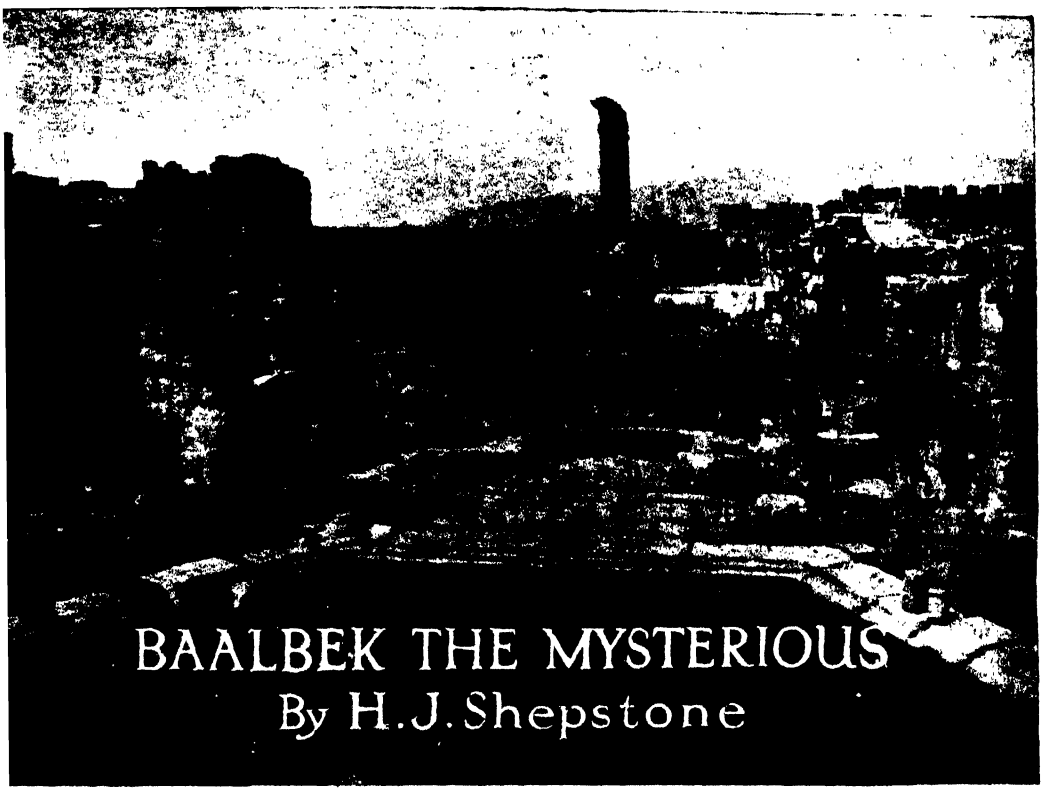
Photo. Sir H. H. Johnston

The Gold and Silver Paradise Birds, Male and Female

Perhaps in some examples of this group (the *Paradiseidæ*) Nature has reached the climax of bird beauty, both in fantastic outline and in colour

there are many graceful plumes and crests, and the colour scheme of the giant heron of Africa is very handsome in its mixture of bright fawn, bluish-grey, white, and greenish-black. Perhaps, however, admittedly the most beautiful of the herons are the pure white egrets, notorious of late for the shocking persecution they have endured at the hands of the plumage traders, with the intent of obtaining the spray-like plumes growing on the back in the breeding-season plumage. There are several species almost entirely, on insects, especially the many noxious flies that frequent the neighbourhood of water, or the ticks and flies infesting the bodies of cattle.

But in asking me to write on Birds of Fine Plumage, the Editor of this work practically invited me to describe and plead for nearly every one of the fourteen or fifteen thousand species of known birds; for to the person with an eye trained to the appreciation of beauty either in form or in colour, scarcely an ugly bird is in existence.



BAALBEK THE MYSTERIOUS

By H. J. Shepstone

A General View of the Ruins of Baalbek

Two Little-known Temples of Ancient Syria, in the Construction of which were used the Largest Building Blocks ever Employed

UNIQUE among the many wonders of the Orient and remains of hoary civilisations stand the ruins of Baalbek, that mysterious Syrian city whose history is lost in the thick obscurity of a very remote past. They are rightly renowned for their massiveness and for the great amount of both bold and delicate carvings with which they are adorned. It is in their grandeur and impressiveness that they differ from the ruins of Palmyra, Petra, Luxor, or Karnak, for in these old Syrian temples we find the largest building blocks ever known to have been used by man.

Situated in the fertile plain of El Bekaa, at an elevation of 4,500 feet above sea-level, in the picturesque valley of the Litany, the ruins are somewhat off the beaten track of tourists, and for that reason are only occasionally visited. They lie close to the present town of Baalbek, a typical Eastern city, boasting of some 5,000 inhabitants. For some four years past a band of German excavators, under Dr. Sabeisheim and Professor Puchstein, have been toiling among the ruins here, with the result that they have thrown much new and interesting light upon the history of this once famous city. Indeed, these savants may be said to have done for Baalbek what Layard did for Nineveh and Babylon, and Schliemann for ancient Troy.

Here, in the days of Solomon, Baal was worshipped. This we know from ancient Assyrian and Egyptian inscriptions. Then came the Greeks, who among these Syrian hills worshipped Helios the God of the

Sun, naming the city Heliopolis. After them came the Romans, who bowed the knee here to Jupiter. The early Christians worshipped at Baalbek, turning the temple into a Christian shrine. They, in turn, were driven out by the Arabs, who converted these wonderful old temples into fortresses, and also erected here a beautiful mosque, of which the ruins remain.

The Temple of Bacchus, sometimes called the Temple of the Sun

Although we know all this, we have really very little knowledge of ancient Baalbek. There is no documentary evidence in existence telling us of the grandeur of its buildings and the people who dwelt among them and worshipped in its temples.

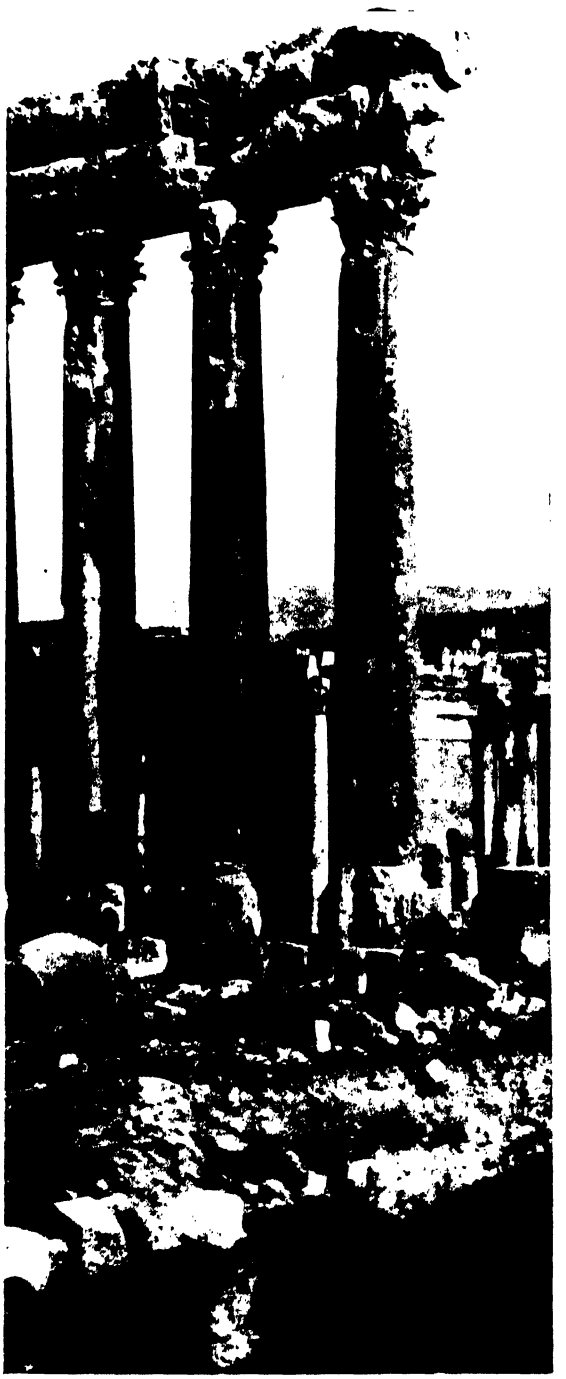
The very extraordinary silence of the ancient Greek and Roman writers concerning a place so extensive, wealthy, important, and magnificent is unaccountable. Nearly all that has been handed down to us is fable and myth. By some, for instance, Baalbek is said to stand on the site of the Enoch founded by Cain, and rebuilt immediately after the Flood—in which case it is decidedly the most ancient city known to history. Others have identified it with Babel, whose top it was intended should "reach unto heaven," while many Oriental scholars have declared it is the Baalath built, or rebuilt, by Solomon. Inscriptions found by the German excavators would go to show, however, that the great buildings, which in their splendour must have been among the wonders of the ancient world, were begun by the Romans in the first century after Christ; and this view is also confirmed by the Syrian writer, Michel Alouf, who is a native of Baalbek, and has devoted an immense amount of time to the patient study of all documents

bearing upon the history of his birthplace.

What most surprises the visitor to these wonderful ruins, perhaps, is the fact that the massive columns, marble doors of prodigious dimensions, fragments of arches, cornices, capitals, and the entablatures which he beholds, only represent the remains of two grand temples—the Great Temple or Temple of Jupiter, and the Temple of Bacchus, sometimes called the Temple of the Sun. Nevertheless, in the colossal walls of this ancient Syrian acropolis one could place all the ruins of ancient Rome. The architecture of four, if not five, ages are represented—Phœnician, Græco-Roman, Christian, and Saracenic—while some authorities consider that there are distinct traces of Solomonic architecture.

The ruins of this magnificent acropolis are built on an artificial oblong plateau of masonry, probably of Phœnician origin, about 330 yards long by 200 broad, and varying in height from 15 to 30 feet and more. The enormous extent of this vast *enceinte* may be better realised when it is remembered that the main courtyard, which served as the approach to the Great Temple, is nearly 150 yards long and some 120 yards wide, dimensions only surpassed by those of the great temple of the Egyptian Karnak. Beneath this colossal platform are vaulted passages, like tunnels, and until recently it was from these underground chambers that the temple area was reached.

First and foremost among these ruins, therefore, comes the Great Temple. Its main entrance was from the east. Here a wide flight of steps led up to the propylæa, 19 feet above the gardens and orchards that now surround the ruins. This portico was opened to the east the full width of the stairs, and the worshippers used to enter between rows of columns, on the bases of three of which



Compare the mighty pillars of the Great Temple (which stand on a platform 40 feet high) with those of the Temple of Bacchus beyond

are inscriptions stating that the temple was erected to the "Great Gods" of Heliopolis.

When the warlike Arabs conquered the city they converted these temples into fortresses and, to a certain extent, they were remodelled. The columns mentioned were removed, the staircase was taken away, and the material used to construct a solid wall where the columns had been. The excavators have torn down the wall constructed over the bases of the columns, and built a narrow staircase where the broad old one used to be, so that to-day one enters again as did the Roman worshippers of old. Indeed, every visitor to the ruins to-day owes the Germans a debt of gratitude, for in removing the Arabic work they have made the original plan of the ancient builders more easily comprehensible.

From Temples to Fortresses

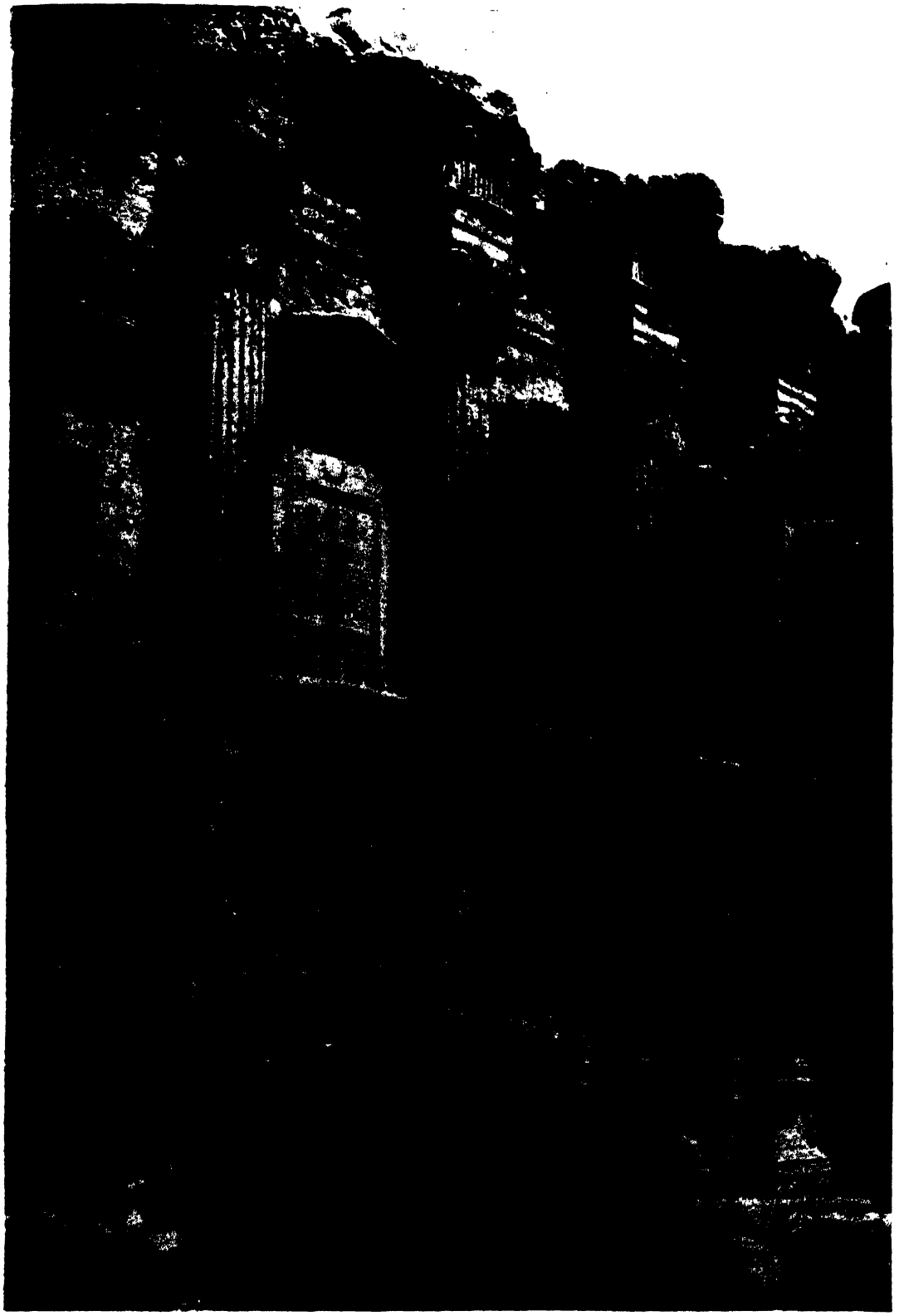
From the propylæa one passes to the hexagonal forecourt by means of a central doorway, with a smaller one on each side. This small court was surrounded by a colonnade, and on four of the six sides by exedræ, or lateral chambers. The Arabs also blocked this threefold entrance, and converted the exedræ into fortifications.

Proceeding inward, one passes through a triple entrance into the Great Court, or Court of the Altar. Some idea of its immense size may be formed when it is stated that it measures 400 feet in length, and is about 370 feet in width—a larger area than that occupied by St. Paul's Cathedral. The central portal, as well as one of the smaller side portals, has fallen in, and the pieces which formed the arches have been collected and laid together on the ground below the places where they had originally been. Around this great court, on three sides, omitting the west end, where a staircase led up to the level of the Great Temple beyond, are square and semicircular exedræ, which each contain many handsome niches for statues, of which, unfortunately, not a single example remains. These vestibules were resting-places for the devotees who came here to worship. In front of these exedræ ran a colonnade of polished Egyptian granite, surmounted by an entablature, bearing carvings of rare beauty. The columns have all fallen, and now, with fragments of their entablatures and capitals, strew the court.

In the centre of the court, rather nearer to the steps ascending to the Temple beyond, stands what is left of the large altar. On each side of it is a pool or basin, used for ablution in connection with the religious rites here observed. It was only during the recent excavations that the altar was discovered, and also the steps by which the priests ascended at the time of sacrifice. When these temples were taken possession of by the early Christians, a church was erected over this altar; part of the latter was destroyed, and the space levelled up with earth, so that the church floor was above the top of the altar.

From the spacious court one passes, by means of a wide flight of steps, into the Great Temple itself. Nothing now remains of it save six columns, which formed part of the peristyle; these still stand *in situ*, capped with Corinthian capitals, and joined by an ornate and massive entablature. They are, perhaps, the crowning feature of Baalbek, and piercing the skyline, as they do, are seen long before the ruins are reached. Professor Taylor says of them: "I know of nothing so beautiful in all remains of ancient art as these six columns. From every position, and with all lights of day or night, they are equally perfect." From a little distance their perfect proportions make them appear smaller than they actually are. A wall forty feet high forms a fit pedestal for these magnificent columns. They are 7½ feet in diameter, and, with their bases and capitals, tower about 70 feet into the air, the whole being crowned by a graceful entablature

The Great Temple



Carvings in the Temple of Bacchus

The well-preserved mural tablet with an inscription is modern; it commemorates a visit paid by the German Emperor in 1898

or cornice 17 feet in height. Each shaft consists of three separate pieces of stone, held together with iron. How the ponderous stones which form the colossal cornice were raised in position, and placed across

tion, its walls still standing, as well as many of its columns. It had no court, and was entered by a flight of steps from the east. The walls of the cella, which is oblong, are quite plain on the outside, and are built of

Columns of the Great Temple, Baalbek

These six columns are all that remain of the Great Temple. They are 7½ feet in diameter and tower some 70 feet into the air. (See page 465 for opposite view of these columns)

the six gigantic but graceful columns, is a problem which has puzzled engineers as much as savants and antiquarians.

The Temple of Bacchus, which lies to the south of the Great Temple, entirely independent of it, and on a lower level, is in a far more interesting state of preserva-

carefully-dressed stone, the joints so perfect that a knife-blade cannot enter between. Around this, at a distance of ten feet, runs, on the two sides and ends, a row of smooth columns, which form the peristyle. These, including their capitals, are about 52 feet high, and are surmounted by a magnificent

entablature, and connected with the walls of the cella by enormous slabs of stone, which are elaborately carved with the heads of emperors and deities, and interwoven with floral designs, forming a unique ceiling. While the walls of the cella are still perfect, more than half of the columns forming the peristyle have fallen, the north side being the best preserved. Here may be seen a curious leaning column. It fell against the wall of the temple about a hundred years ago, and, though it partly broke through the wall, yet the two stones composing it were so firmly put together by the ancient builders that the shaft remains unbroken. In a niche, between two pillars of the temple wall, may be seen a tablet commemorating the visit of the German Emperor to these ruins in 1898.

Ruins of the Old Mosque, Baalbek

Notwithstanding the profuse ornamentation of the peristyle, it is exceeded by that of the portal to this temple, which is indeed the gem of the entire edifice. The door-posts are carved with interesting figures of Bacchus, fauns, cupids, satyrs, and bacchantes, around which are woven vines and clusters of fruit, also poppies and ears of wheat, all of which are symbolical of the revelling which the temple suggested. This great doorway stands 43 feet high and 21½ feet wide, while the carving of the posts just mentioned covers a space of about 6 feet in width.

As already stated, these two wonderful ancient temples stood on a raised platform, resting on substructions. The Great Temple lies 44½ feet above the level of the plain, and is the highest part of the entire enclosure; while the Great Court was only 23 feet lower down. An enclosing wall, the mammoth stones of which have been the marvel of engineers for ages, deserves mention. The lower courses are of stones of moderate dimensions, but they grow rapidly in size, until we come to a row of three enormous blocks, the shortest being 63 feet, and the longest 65 feet in length, each being about 13 feet high and 10 feet thick. The course of which they form part is 20 feet above the surface of the ground. They are the largest blocks ever known to have been used by man.

The Flight from the Flames after the Great Earthquake at San Francisco

(Drawn by W. Russell Flint)

Earthquakes are no respecters of persons. Millionaire and labourer alike were driven from their homes and forced to take refuge in the public parks, whence they watched the burning of their city. Science and engineering were helpless to cope with the twin catastrophe Only the veering of the wind saved the city from complete destruction

Earthquakes

Waves in the Earth—Their Cause and Awful Consequences

By ARTHUR HOLMES, F.G.S., A.R.C.S.

Author of "The Age of the Earth"

WAVES and ripples are to be found in the solid earth, no less than on the mobile surface of the ocean waters. The earth readily responds to any disturbance on its surface, and is, in consequence, in a perpetual state of tremor. The tread of an army, the ebb and flow of the tide, the sudden impact of wind and wave, the passing of an express, all of these everyday incidents suffice to make the earth tremble. Such effects are, however, purely local, and so minute may be the vibrations that only with the aid of the most delicately-poised instruments can they be detected. They may be compared to the film of ripples which spreads over a pond when a gentle breeze flits lightly over its glassy surface. If, however, a heavy stone is dropped into the pond a series of waves is generated, and each travels outwards till it breaks against the side. So, when a sudden dislocation takes place in the earth's crust, a series of waves emanates from the centre of disturbance and spreads in all directions, until the shock reaches the surface and is felt as an earthquake.

Photo: Illustrations Bureau

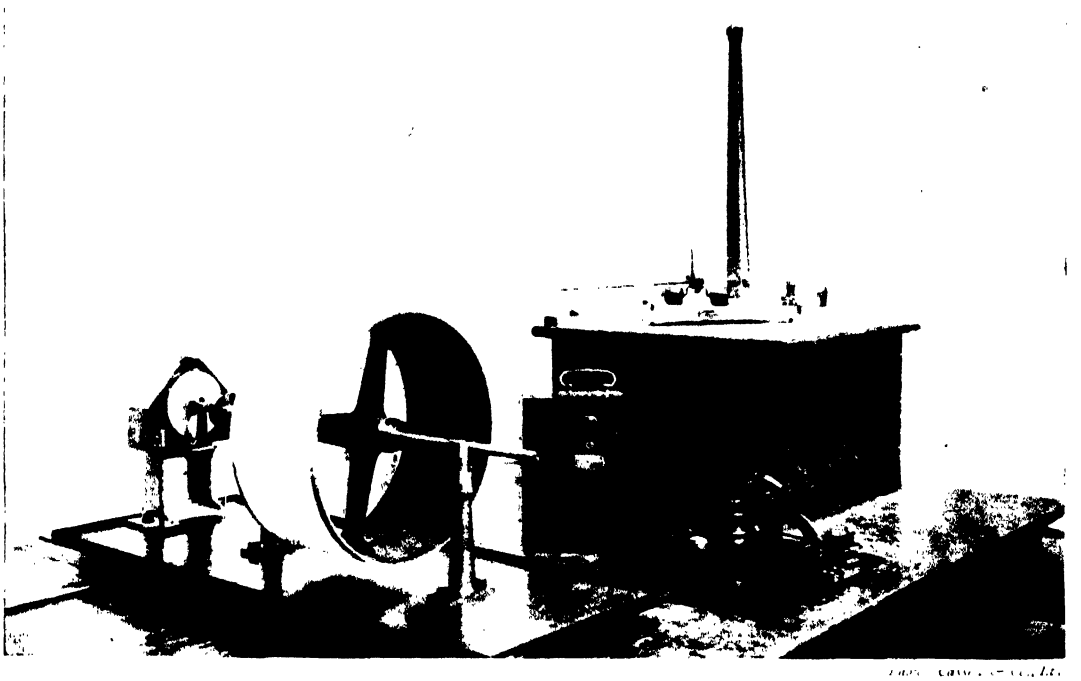
A Shattered Home at Messina

Within a few seconds of the first alarm the front of this substantially-built house fell from it as if dynamited

In extreme cases the whole earth is shaken, and the waves, before dying away, may reach the Antipodes, not only by rolling around the surface, but also, more quickly, by taking the direct path through the heart of our planet.

The awful catastrophe of a heavy earthquake comes almost unheralded. It has often been recorded that domestic animals experience great terror and uneasiness before the onset of a shock, and, although their prophetic ability has been doubted, it seems probable that, with their acute senses of smell and hearing, they should detect the faintly odorous vapours which escape from the ground, and the mysterious prelude of noises before the subtle warnings are recognised by their human masters.

The first premonition of coming disaster proceeds from the earth as a dull, booming sound, like distant thunder, or perhaps as a strange lowing like the confused roar of a great city. But the warning is too late, for almost at once the ground begins to quiver and heave, and a low but rapid wave swells over the surface, carrying death and destruction on its bosom. Professor Hobbs gives a graphic description of the appalling horrors of an earthquake. "Unable to keep their feet, men and beasts alike lie prostrate upon the ground and are seized with nausea akin to sea-sickness. To the rumbling of the earthquake there is quickly added, in cities, the crash of falling masonry, and to this succeeds an uncanny grey darkness as the air becomes filled with the dust from broken bricks, mortar, and plaster. In places, the ground opens and swallows the objects which lie upon it. Ponds are sucked down and disappear. . . . Disagreeable and unsanitary odours are freed from decaying organic matter within the soil, and these fill the air with an intolerable stench. In the fraction of a minute all the destruction has been wrought, and as the grey curtain of



Professor Milne's Seismograph, or Automatic Earthquake Recording Machine

This comparatively simple apparatus consists of a clockwork-operated revolving drum of bromide photographic paper, over which is lightly suspended a horizontal pendulum

dust slowly lifts and reveals the once prosperous city, there is disclosed a scene of desolation and misery which beggars description."

One of the earliest human records of an earthquake is the Biblical account of the destruction of Sodom and Gomorrah, cities so wicked that in one of them not ten righteous men could be found. And so for their exceeding great wickedness, "the Lord rained upon Sodom and upon Gomorrah brimstone and fire from the Lord out of heaven; and he overthrew those cities and all the plain, and all the inhabitants of the cities, and that which grew upon the ground." It is curious that the description suggests a volcanic eruption in addition to the earthquake, for at the present day no volcano is to be found within two hundred miles of the locality.

It is possible the Noachian Deluge was partially due to great sea waves, engendered by a submarine earthquake, and as the Assyrian account of this great catastrophe admits of such an interpretation, it seems probable that the story of the Flood is the oldest record extant of a disastrous earthquake.

The earliest attempts to probe the mystery of earthquakes were either deeply imbued with the religion of the people, as in the case of the Israelites, or were merely fantastic explanations based on creation myths. Subterranean monsters were believed to move in the under parts of the earth, and so to produce the heaving of its surface. The ancient Mongolians supposed that the earth was supported by a gigantic frog. In Japan the monster was variously described as a great spider, as an immense catfish which, when angry, dashes violently against the coast, or as a dragon which lashes its tail against the sides of the cavern in which it dwells. In North America it was a giant tortoise which shook the earth, and in South America a whale.

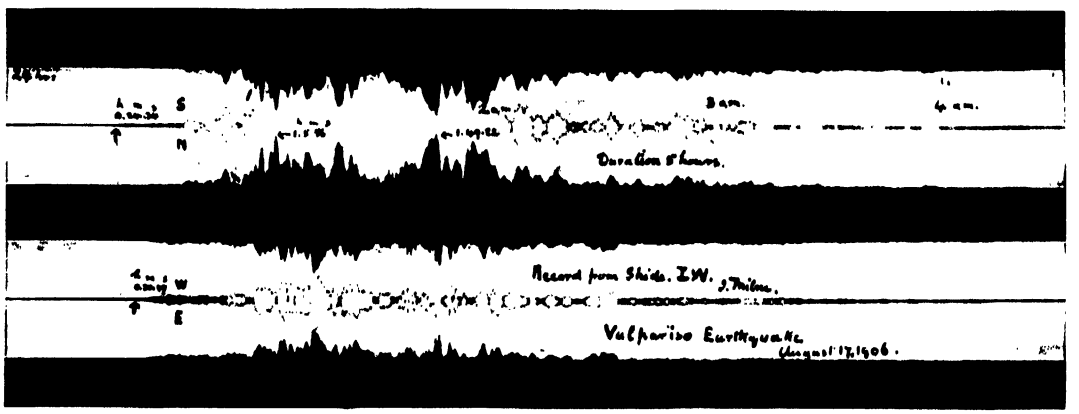


Photo: Illustrations Bureau

An Earthquake's Autograph

The admission of light through a slit over the pendulum causes a straight black line to be recorded (on developing the paper) when it is at rest. By communicating tremors to the earth an earthquake, thousands of miles distant, makes the pendulum vibrate, with the result here shown

The Greek philosophers attempted to find a more natural explanation of the earth's sudden convulsions. Lucretius believed that the earth above and below was filled in all its parts with windy caverns. Here were to be found lakes and chasms, cliffs and crags, and rivers heavily charged with submerged stones, rolling violently through this subterranean world. In the course of time the vast caverns became undermined, and whole mountains fell in with a mighty shock which set the earth rocking and swaying. Also, an enormous

force of wind may hurl itself into the hollow of the earth, and there, lashed into fury, it tries to burst open its prison, and with a great uproar tears away a great yawning chasm.

This type of earthquake theory was held for seventeen centuries, and we find Shakespeare speaking of "the teeming earth . . . pinch'd and vex'd. By the imprisoning of unruly wind . . . which, for enlargement striving, shakes the old beldam earth, and topples down steeples and moss-grown towers."

Shakespeare's Theory

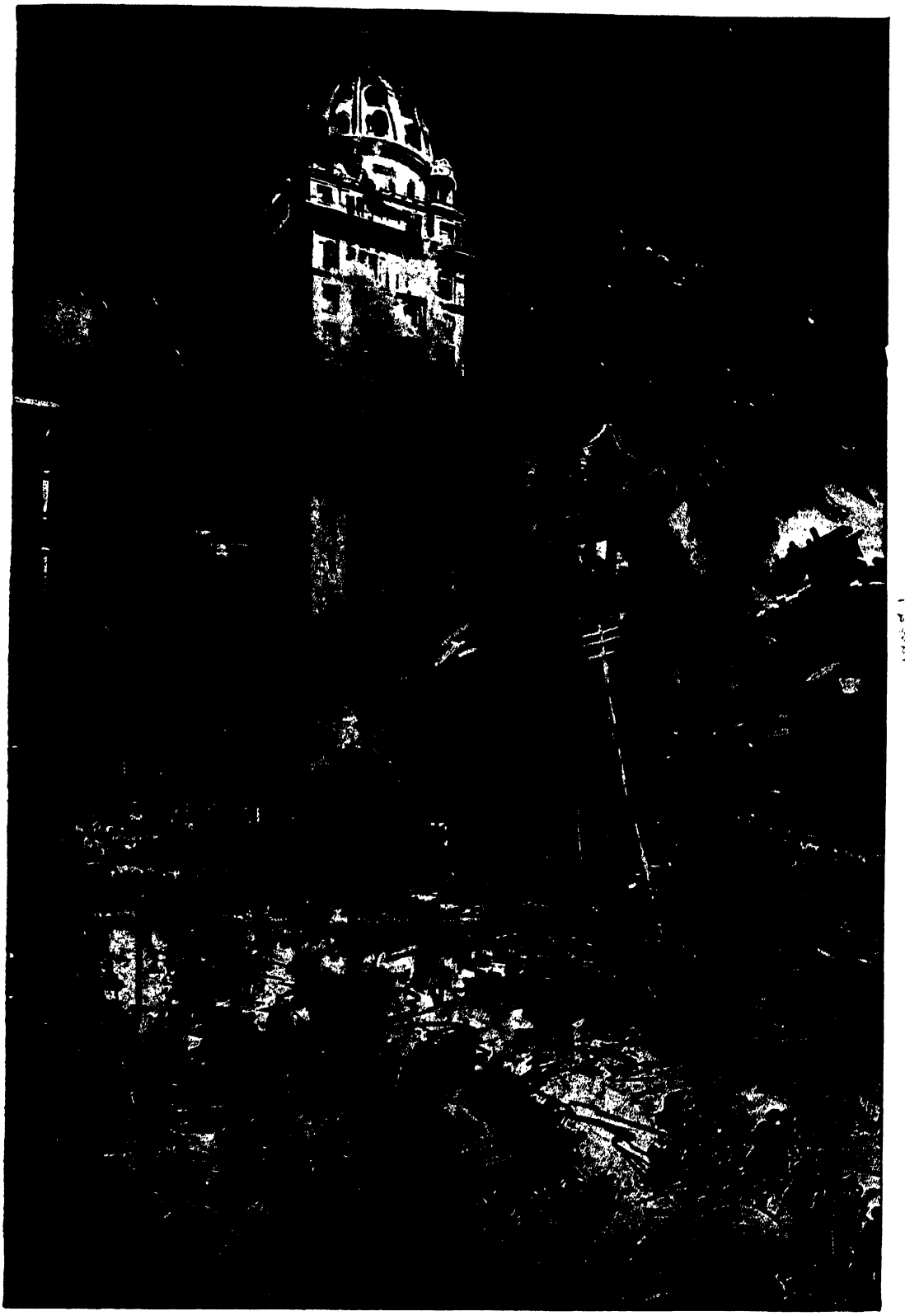
The modern scientific study of earth quakes began little more than fifty years ago, but before outlining present-day opinions, let us consider briefly one or two of the great earthquakes of recent times.

The lower valley of the Tagus is remarkable for the great number of destructive earthquakes by which it has been shaken in historic times. Most serious of all was the great Lisbon earthquake of November 1st, 1755. A deep rumbling noise appeared to come from underground, and this insufficient warning was almost immediately followed by a violent quaking which demolished the beautiful city almost completely. In six minutes 60,000 people lost their lives. Hundreds of worshippers sought refuge in the churches and were buried beneath the shattered masonry where they stood. An immense crowd gathered on the marble quay, hoping to escape from the sudden overthrow of the buildings. Without warning, however, a fissure opened beneath them, and the quay, with its human burden, sank into the water and was engulfed. The bodies were probably sucked into the chasm and buried when it closed up, for not one was ever seen again. Great stretches of the coast fell away into the sea, both to the north and the south of Lisbon, and mountains in the neighbourhood were rent and fractured so that great avalanches of rock were hurled into the valleys. The effects of the earthquake were felt over an enormous area. In France and Morocco deep fissures were opened out, and in Scotland the waters of Loch Lomond rose and fell in sympathy with the shocks.

At Lisbon a further disaster still awaited the stricken city, ready to take its toll of life. Half an hour after the first shocks the sea retired from the land to feed a huge wave, 60 feet in height, which had been raised by the earthquake, and which was now rolling in from the ocean. It rapidly advanced, the most formidable wall of water that had ever been seen, and in a few minutes the annihilation of the city was completed. This wave, and others like it, reached the shores of three continents, with destruction in their angry crests, so far did they travel and so violent was the manner of their birth.

The great disaster which rudely awakened the inhabitants of San Francisco in the early morning of April 18th, 1906, must still be fresh in the minds of everyone. This frightful earthquake lasted for less than two minutes, but in that time a large part of the city was irretrievably destroyed. Houses were caught in the grip of the earthquake and violently shaken. Spires were rent, and scarcely a chimney held. Everywhere the outer veneer of masonry fell away from the buildings, leaving behind a skeleton of steel ribs—they, at least, were nearly earthquake proof. Great crevices were torn in the streets, roadways sank far below the pavement, tram rails were torn and twisted; but, worst of all, the underground gas and electric systems were shattered, and fires broke out almost immediately. The water-pipes and mains were similarly rendered useless, and the fires could not be held in check. A gigantic conflagration spread over the city, hissing and roaring, and continued for three days. An attempt to save part of the city was made by clearing a zone around the fire, but dynamite gave out and it seemed more furious than before. The

San Francisco



The Great Earthquake at San Francisco, April, 1906

This frightful earthquake lasted for less than two minutes, but in that time a large part of the city was irretrievably destroyed. The underground gas and electric systems were shattered, and fires broke out almost immediately. The picture shows the burning of the "Call" building in Market Street

city would have been doomed had not the wind veered and driven the fire back.

A Common Error

It is often thought that earthquakes and volcanic eruptions are intimately connected. However, the two examples we have just passed in review are outstanding cases of earthquakes which originate in districts unvisited by volcanic activity. Indeed, volcanoes are generally free from heavy shocks, though minor shocks and local tremors are numerous. It is in areas where there are no volcanic vents to relieve the accumulated earth stresses that the most destructive earthquakes occur.

In examining the rocks of almost any country, it is usual to find formations which show, by their fossil inhabitants, that they were originally deposited upon the sea bottom. Often these strata are folded and crumpled, broken and displaced, and yet it is clear from the geology of the surrounding district that no volcanic action was associated with the movements. The rocks themselves are eloquent witnesses of the earthquakes which attended their distortions. It is, in fact, with the most recent systems of folded mountains that modern earthquakes are most closely connected.

There are two important zones susceptible to movement. The first includes the Mediterranean Sea and the Alpine system of mountains, and extends eastwards through the great ranges of the Caucasus and Himalayas. This unstable zone represents a belt which long ago in the history of the world was occupied for millions of years by a great sea, a vast Mediterranean, of which the present Mediterranean is but the shrunken relic. Here was accumulated layer after layer of sediment until a great thickness had been deposited, the raw material of the mighty ranges which now lift their snow-clad summits above the clouds. Here, after long ages of sedimentation, the deeply buried formations began to struggle for freedom. Heated by the depth to which they were depressed, and by the radium which was buried with them, they gradually expanded and buckled up into folds. Mountain building had commenced. Nor is the process yet completed. The earth-forces are still unrelieved, for the earthquakes of to-day are themselves the most convincing testimony of the mobility of the crust throughout that extended region.

The second belt surrounds the Pacific Ocean and includes the island festoons of eastern Asia, and Australasia, and the great Cordilleras of North and South America. It may seem that the earthquake belts correspond so closely with the volcanic zones that our former statement that volcanic districts are relatively free from heavy shocks would appear to be discountenanced. The connection between these two catastrophic phenomena is not one of cause and effect as a general rule, but one of common origin. In each case the stresses set up by a rising temperature have to be relieved. If the temperature is high enough to fuse the rocks, the molten materials force their way through the fractures of the outer crust, and a volcano results, a giant pore through which the earth sweats out her superfluous energy. If the temperature does not attain to the fusion point, or if the molten rocks are unable to force a vent through the massive roof which imprisons them, then a dislocation takes place like a spring suddenly broken or relieved, and a mighty earthquake wave shakes the earth to its very heart.

Tremendous Pressure

Most earthquakes originate at a depth of less than ten miles. This is precisely what one would anticipate from geological considerations, for at depths not much greater than ten miles the pressure becomes so great that no crevice or microscopic pore is any longer possible. Under these conditions rock would never fracture, as it would in the upper zone, but would flow like treacle.

The Wonders of a Battleship

Facts Concerning the Most Powerful Thing Afloat

By HORACE C. DAVIS

THE modern battleship stands forth as one of the greatest wonders of man's toil and ingenuity. Into a vast whole enter in one way or another all the metals from the roughest iron to pure gold, all the woods from the commonest deal to the most expensive oaks and mahogany, and all the fabrics from canvas to silk, and, more important still, labour, that costs most of all. From the time her plans are drawn out, in greatest secrecy, through months of labour and noise in which she grows from a long keel plate to a maze of ribs, which are later enclosed by the side plating and deck, she thunders with sound and is full of busy life. After a year's work some great lady will give the ship its name and set her on the waters. Thus the battleship is born, and whilst afloat, just a stark naked hull, she is filled with her propelling and death-dealing machinery that will be her pride and glory when, after another year, she steams away to sea for her trials; these will conclude with the great ship hoisting the white ensign and standing forth as the latest and greatest of her kind.

Yet so progressive is the march of naval shipbuilding that, within the space of a few short months, a younger and even greater sister will have left *her* birthplace, and usurped the proud position the other ship has held for so short a period.

To take a peep at one of these monsters is to enter a world that is practically unknown to the landsman. Quite truly it has been said that, notwithstanding the fact

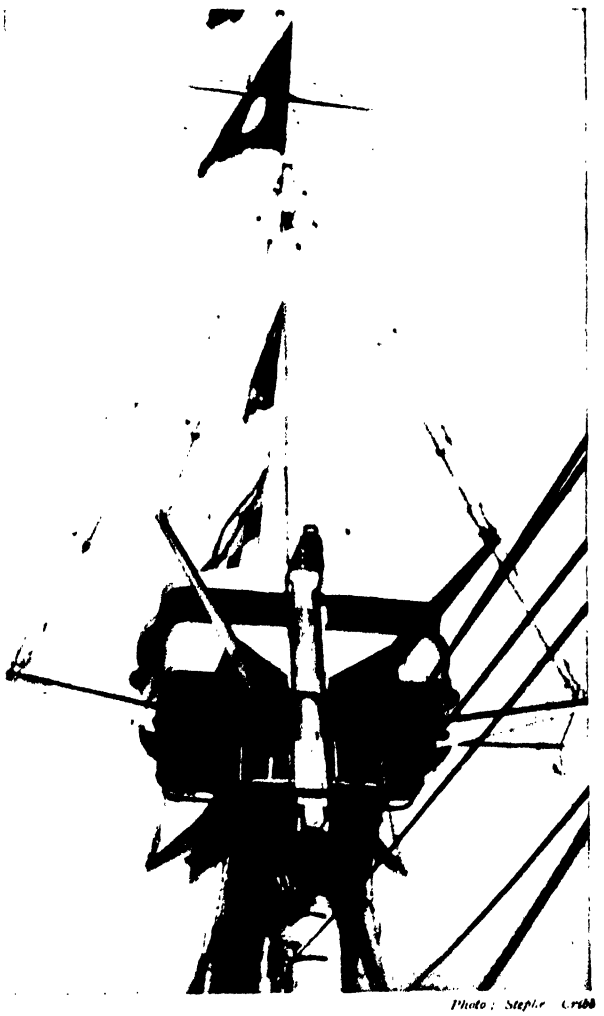


Photo : Stephen Cribb

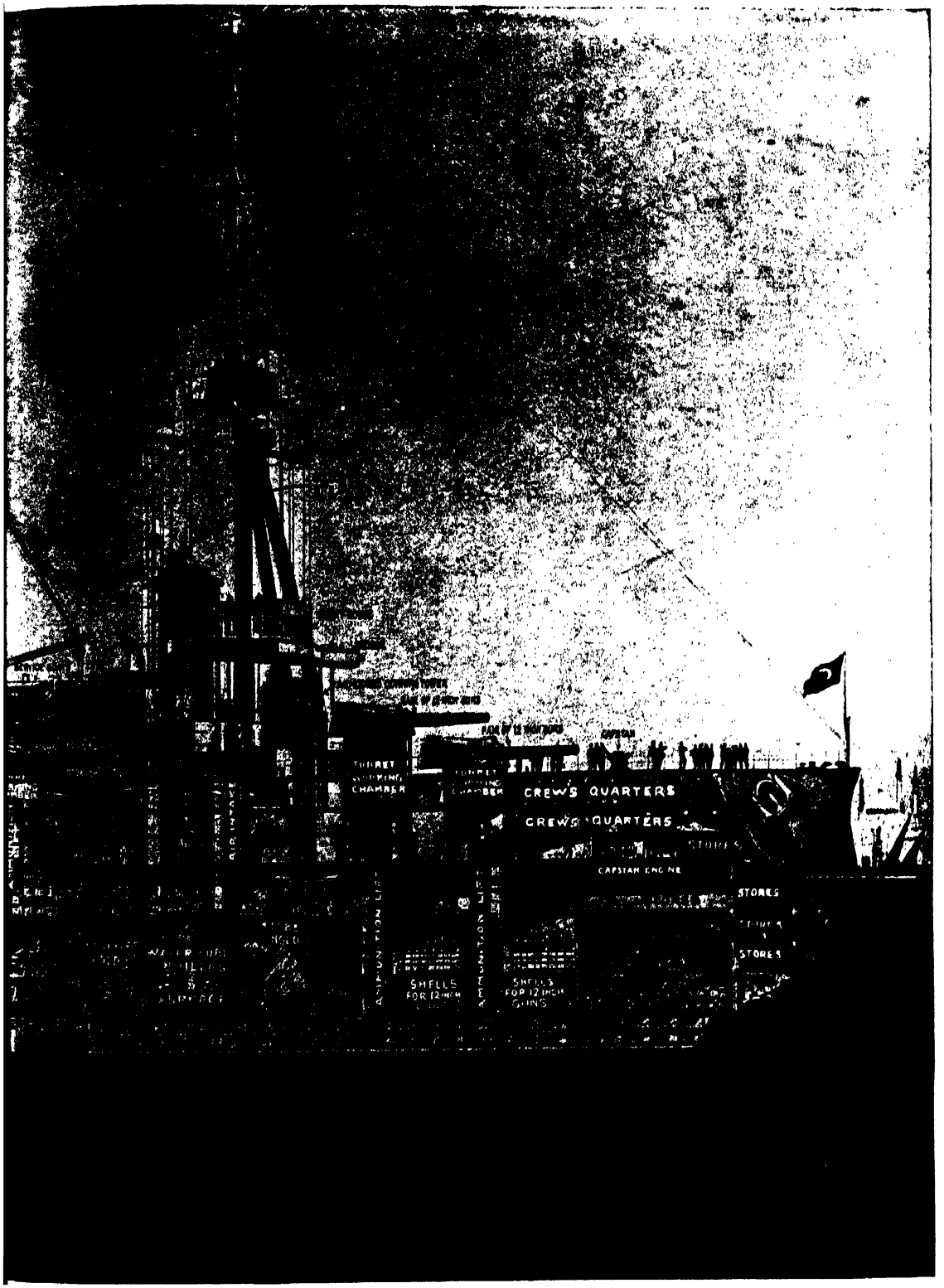
The Director Platform and Control Top of H.M.S. "Neptune"

Here are stationed the range-finders who telephone or signal information down to the gun turrets on deck

SECTION SHOWING THE INTERIOR (

(Draw

This sectional view of the very powerful *Rio de Janeiro*, bought by Turkey from Brazil while still un displacement is 27,500 tons; her speed is 22 knots; her length is 632 feet. She can



A DREADNOUGHT AT A GLANCE

Charles de Lacy)

completion at the Elswick Yard, makes clear all the details described in this article. The *Rio de Janeiro's* fourteen 12-inch and twenty 6-inch guns. Her complement of crew should number 1,000 men

Wonders of a Battleship

that Great Britain pays more and depends more upon her Navy than any nation in the world, the man who puts his hand in his pocket to contribute his share of the cost has but a very hazy idea of the strange floating world, armed, armoured, trained, and undoubtedly efficient, that is nothing more or less than his greatest insurance policy.

A Population of 1,000 Men

Step aboard; note the spacious deck, the crowd of seamen who are part of the population of close upon one thousand men, and, above all, observe the grim guns that are the greatest power of this monster ship. These guns are all on the centre or keel line of the ship, so that each can fire at almost any angle and have a big sweep of the horizon. In all our latest and greatest ships the guns are super-imposed, that is, the guns in the second turret from the bow and the second turret from the stern fire over the turrets of the forward and after guns. This means that, in chase, four guns can be brought to bear on the enemy ahead.

Now climb through the small aperture that forms the entrance doors to these barbettes and get inside, shut from the outside world by twelve inches of the hardest steel that modern methods can produce. Here is a busy space, populated by less than a score of men who have chained to their will two mighty weapons, each capable of throwing a projectile with deadly accuracy to a distance of eight miles, and with a tremendous bursting charge and shell of 1,400 lb., filled with the latest form of chemical explosive. The officer commanding the turret sits on his tiny seat out of the way; a small tube not unlike the periscope of a submarine passes through the hood of the turret and conveys the scene outside to his eye. Before him are telephones and dials that speak to him in a strange language which he understands. High above his head are the range-finders in the control top, perched dizzily at the apex of the tripod mast; provided with delicate and intricate instruments, they are able to detect the range to a nicety. The information thus gleaned by their superior range of vision is telephoned and signalled by electricity to the captain of the turret. Either by hydraulic or electrical power the shell is brought from the shell room right down in the bowels of the ship on a miniature lift. Immediately this tray, with its death-dealing burden, comes opposite the breech of the gun, which is automatically opened, a rammer drives the shell home, and, in a matter of seconds, the explosive charge follows. The breech clangs and locks by the same movement, the electric contact is connected, and the gun ready for firing. When all is ready, it is the simple pull of a gleaming pistol trigger that sends the great shell hurtling through space. Whilst it fills the air with thunderous sounds, the blast is already cleaning the gun for the next round.

The Working Chamber

Once more clamber through the manhole, leave the gunhouse, and give a glance at the working chamber immediately below it, wherein is the swash-plate engine that turns the great turret in any direction desired. So wonderful is the gearing that it can rotate the turntable at a fast speed of one revolution in one minute, or at a slow speed of one revolution in ten hours. Other machines are here to work the ammunition hoists, that pass in trunks through this chamber down to the magazine and shell rooms.

On the latest and greatest British ship there are five of these great gun-houses, all exactly alike, all manned by an equally alert crew, and all a mass of gleaming business-like steel. In addition to this the vessel will carry a secondary battery, consisting of quick-firing guns for repelling torpedo boat attack. The majority of our new vessels are armed with the 4-inch weapon, weighing 26 cwt., and able to

send a shell clean through an on-rushing torpedo-boat 1½ miles away. In later ships the 6-inch gun, a new and wonderful weapon, is mounted; this is necessitated by the rapidly increasing size of modern torpedo craft.

Leave the artillery, which is the chief item (for is not a battleship simply intended to act as a floating platform for guns?), and turn to those dim regions far below the armour belt, down below the water line, an inferno of heat and oily smells, where work the "black gang." The modern fighting ship of the speedy battle-cruiser type will have as many as 48 great water-tube boilers, which are roaring boxes of blistering heat when the vessel is steaming hard. There is the continuous clang of the shovel, there is the intermittent search-light-like glow as furnace doors are opened to examine the fires or add more fuel; there are the oil burners with their pump room above, with engine, pumps, filters, and heaters, and with tanks below in the double bottom to aid the coal with oil should the Admiral suddenly call for speed. There is the roar of a score of draught fans sucking down the necessary air, and along the broadside runs, most wonderful of all, a miniature colliery in full working order, where can be found dim human forms working by the light of Davy lamps, whilst the whole great fabric thunders through the riven seas.

Visit yet another quarter where the Chief Engineer holds sway. Here is yet another domain of oil-smelling heat, with walls lined with miles of steel and copper mains, some gleamingly bright, while others are asbestos covered. Over all rules a clean-shaven officer, and under him are various grades of artificers. Everywhere are dials, and, in different compartments, the vast turbines that rotate the propellers and push the 27,000 tons of metal, wood, and men through the whistling seas.

Penetrate the flats where Jack has "turned in" in his hundreds, in stuffy quarters. Naked and business-like is his bedroom; his bed is a hammock slung from hooks fixed for the purpose, and packed so close that to creep in between the hammocks of this ghostly grove of human sleeping forms would be impossible. To-morrow, before the dawn of the wintry morning, the bugle will call them once more to their day of busy labour, whilst the space where they have slept will be filled with the clatter of mess tables. Observe the cooks and cooks' assistants who prepare meals for this floating town. The kitchen or galley of a battleship is a sight indeed, for close upon a thousand hearty hungry men have to be fed. Examine the bakery, where they make bread that earns praise from every landsman who tastes it; and, yet again, there is the laundry, all driven by steam and electricity. Forward, in all the earlier Dreadnoughts, and aft in the very latest type of all-big-gun ships can be discovered the officer in all his various ranks. Visit the gun-room, come in as an honoured guest to dine with the "Snotties," as the midshipmen are dubbed in the Service; hear a piano banged with the most wonderful of tunes; observe a youth who, but half an hour before, may have been driving a pinnace out of harbour with racing tides, a dirty cross-sea, a sea-haze and hurrying merchant traffic to furrow his brow, dancing a new and weird contortion of the Tango with another of his kind. Here is made the budding Admiral; he knows no privacy; he has no cabin to himself, and he has cost his father some £2,000 to get him there and pay his bills.

Visit the ward-room flat; here are the older lieutenants, who reign over various regions of this wonderful world of floating steel. If it be night the "watch below" are behind their curtains, each in his tiny cabin, with the footfall of the pacing sentry to break the surrounding silence, for the engines are not felt here as they are in the quarters below where the crew are cooped,

A POWERFUL MODERN BATTLESHIP FIRIN

The modern battleship is simply a floating platform for carrying destructive and death-dealing guns. On the lat
secondary battery of quick-firing guns for repelling torpedo-boat attacks; the 4-inch weap

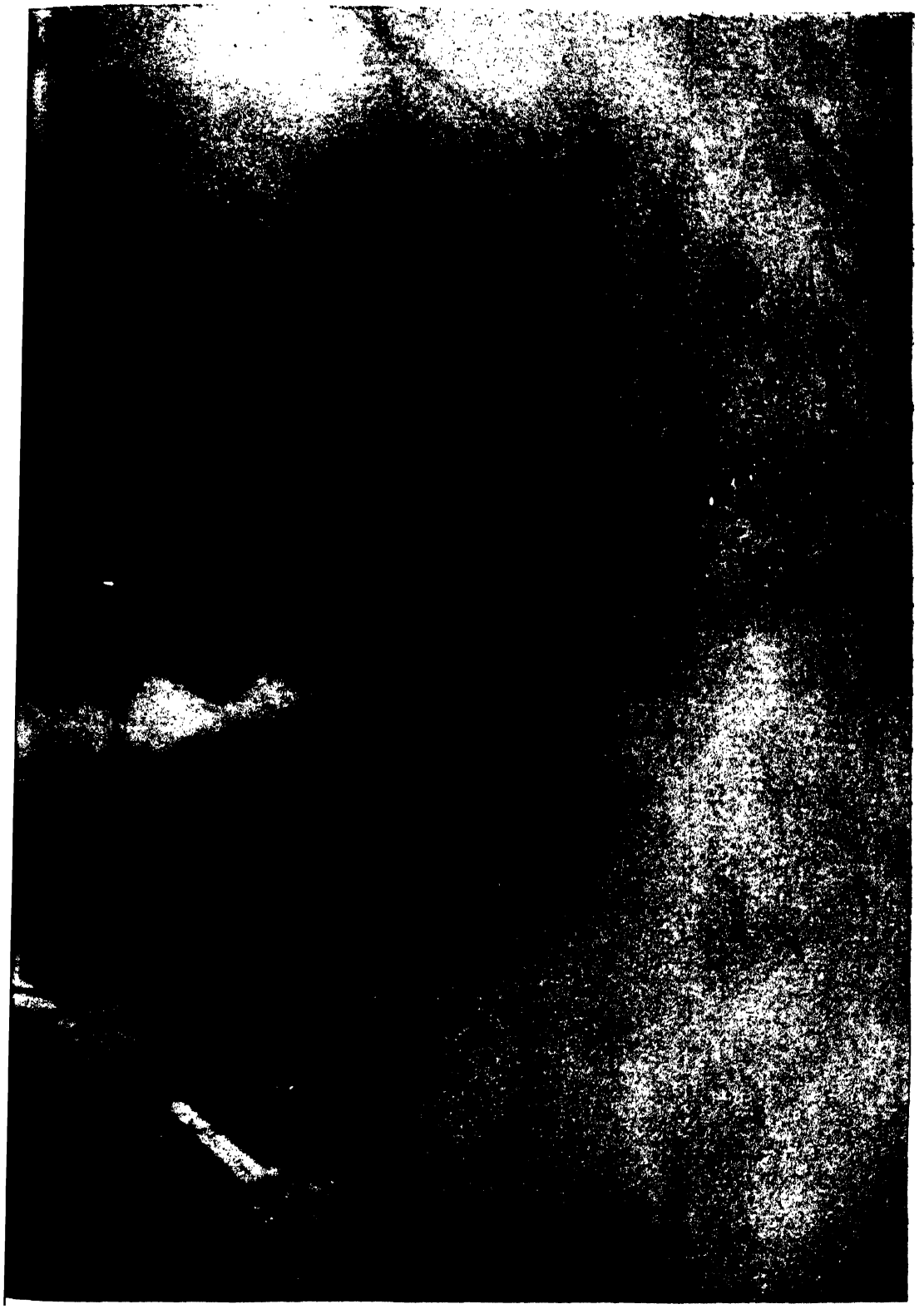


Photo by courtesy of Sir W. G. Armstrong, Whitworth & Co., Ltd.

A BROADSIDE OF TEN 12-INCH GUNS

of British super-Dreadnoughts there are five of these great gun-houses. In addition, there is a onrushing torpedo boat 1½ miles away

Wonders of a Battleship

cabined, and confined. The wardroom is capacious and luxurious; heavy oak and mahogany combine with works of art, silk shades and silver and gold, which, in the day of battle, would usually go overboard so as not to be food for the fire-god, the most dreaded of all foes.

Photo, Gale & Polden, Ltd.

In a Naval Stokehold

Climb to the bridge, small in size, but lofty and airy. If it be day the panorama of the ship is below you; at your back a great fore funnel, big enough to admit a motor-bus, sends a gentle brown cloud into the sky. Aft this are the boats and pinnaces, the great tripod mast with the fire control and director boxes high above, and the aerials of the wireless telegraphy higher still. All the battle squadron are spread out ahead and astern; all the great ships are seething with life, each has its thousand souls, each has its throbbing steel heart, and its gigantic teeth sticking menacingly from their turrets. Each by means of flags and balls are telling one another strange truths of speed whilst the officer in command, pacing the bridge, and the stolid, clean-shaven quartermaster at the puny wheel (that steers so vast a ship by the aid of steam) keep a clear eye on the next ahead. As she drops a little we drop also; the engine speed is up and down, changing from minute to minute. If it be dark, a great beam of light may sweep up from over the horizon, and one of our searchlights answers back by a beam that, in fine clear weather, can be seen a dozen or more miles away.

Such, without too much technical language, is the world of a fighting ship, great and grim, built only to protect us from our foes. In most cases it is built, it lives its short twenty odd years of life, and finally goes to the Mother-bank and after to the shipbreaker without ever firing a single gun in anger. Nevertheless, on these steel monarchs of the sea Britain's greatness depends.

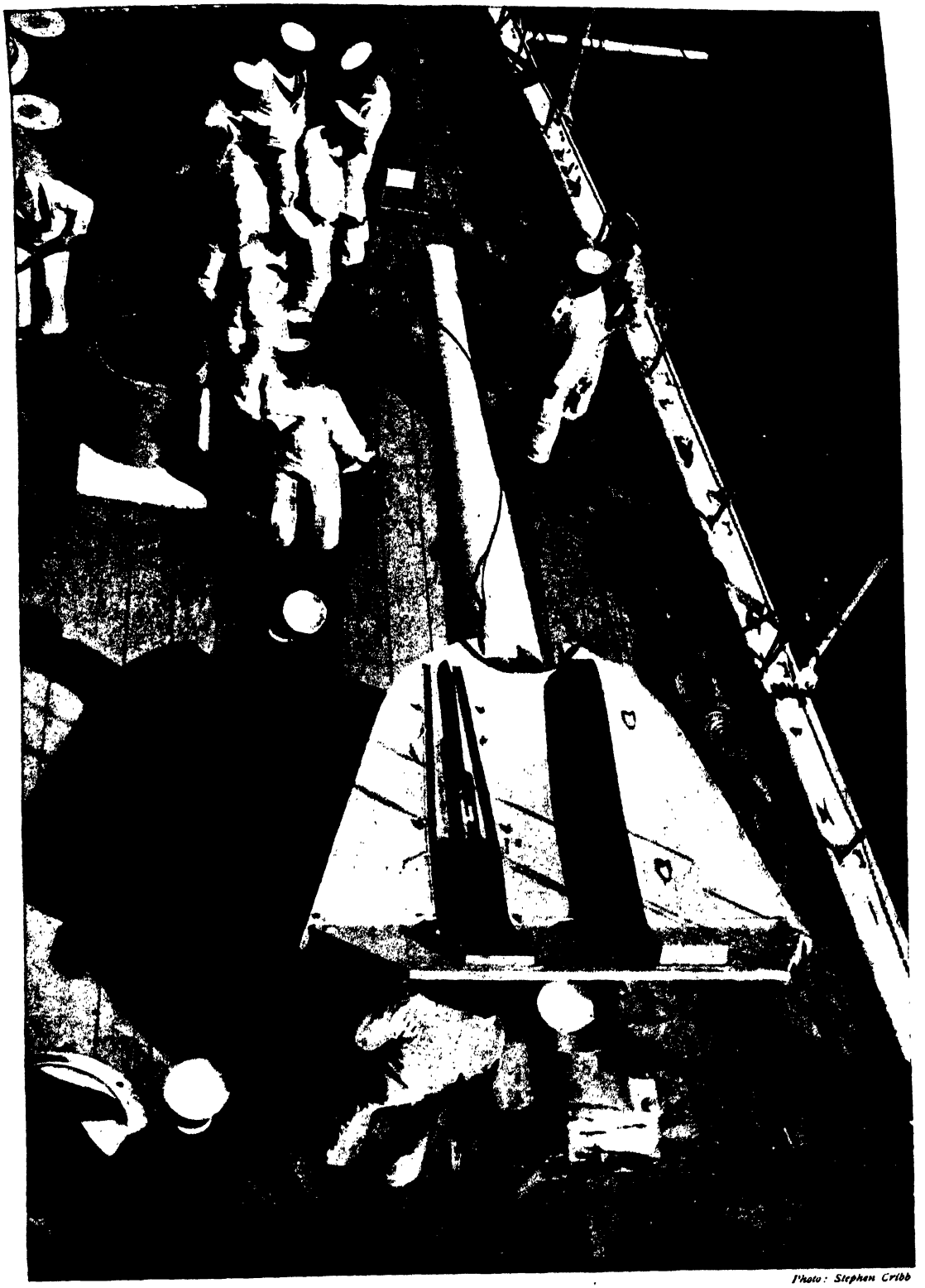


Photo: Stephen Cribb

The Famous "Dotter"

This contrivance consists of a small rising and falling target, close in front of which is an electric pencil connected with the trigger of the gun. As the trigger is pressed the electric pencil darts forward and registers a dot upon the target. If the gun-layer has kept his gun constantly at the correct elevation the target records a perfectly straight line of dots right across it. Thus constant firing practice can be obtained at no cost in ammunition

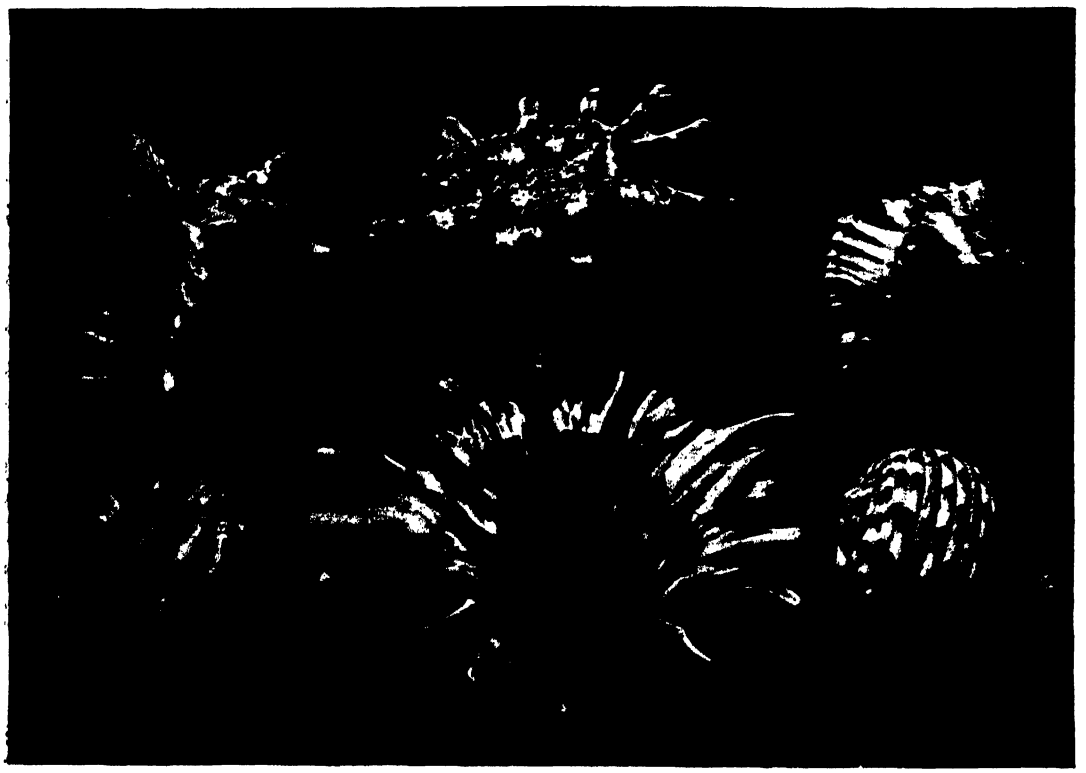


Photo: K. Thiele

Some Fine Examples of Shell Architecture
(See key table on opposite page for names)

The Architecture of Shells—II

By STANLEY C. JOHNSON, M.A., D.Sc.

THE shape and ornamentation of shells was discussed in general terms on pages 274–6; here it is intended, with the aid of photographs and brief notes, to go a step farther and reveal minor features of conchological interest

One picture (80) shows a mussel to which is fastened, by means of a number of silken strands, a quantity of small stones. These threads or byssus clearly indicate the means which this particular mollusc adopts for anchoring itself to piers and jetties. In the present case the mussel was captured as it was being washed along with its burden by the flowing tide.

But the photograph possesses a further interest. At one end of the bluish valve a grey patch tells us that all is not well with the mollusc's shell covering.

All shells possess a protective covering called the periostracum. This surface skin serves as a protection against the destructive effects of the weather and the chemical action set up in the water. Sometimes the skin is so thin as to be unnoticeable; at others, it is thick and very apparent. Fresh-water denizens are usually provided with a tough olive-green epidermis, as these suffer considerably from chemical disintegration. The picture of the mussel swimming with its burden of small stones capitally illustrates an instance of perio-

stracum decay. The epidermis of the mussel depicted here has begun to decay and the unprotected parts will no longer be able to withstand the eroding effects of the salt water.

The thickness and texture of the periostracum differ according to the species. With fresh-water molluscs it is thick and tough, probably because the media in which these dwell are usually charged with large quantities of carbonic-acid gas, a deadly enemy to unprotected shells. In other cases, the covering is (*a*) silky, or fringed with short hairs placed together, (*b*) coarse and rough, (*c*) flaky. A good example of the latter variety is provided by the common razor fish.

Protective colouring in shells is a matter upon which we have already touched, but some mention must be made here regarding the protective shapes of certain molluscs. The thorny oyster (5) possesses a number of prickly spines—a calcareous porcupine, in fact. This fortunate inhabitant of the East Indian seas can roam about at leisure without fear of molestation. Its foes either look upon it as a mass of uninviting fish bones or a delicacy that is best left untouched. It may be added that the brittle nature of the spines allows them to be easily broken off by the movements of the water, a fact which accounts for the frequency with which imperfect specimens are met.

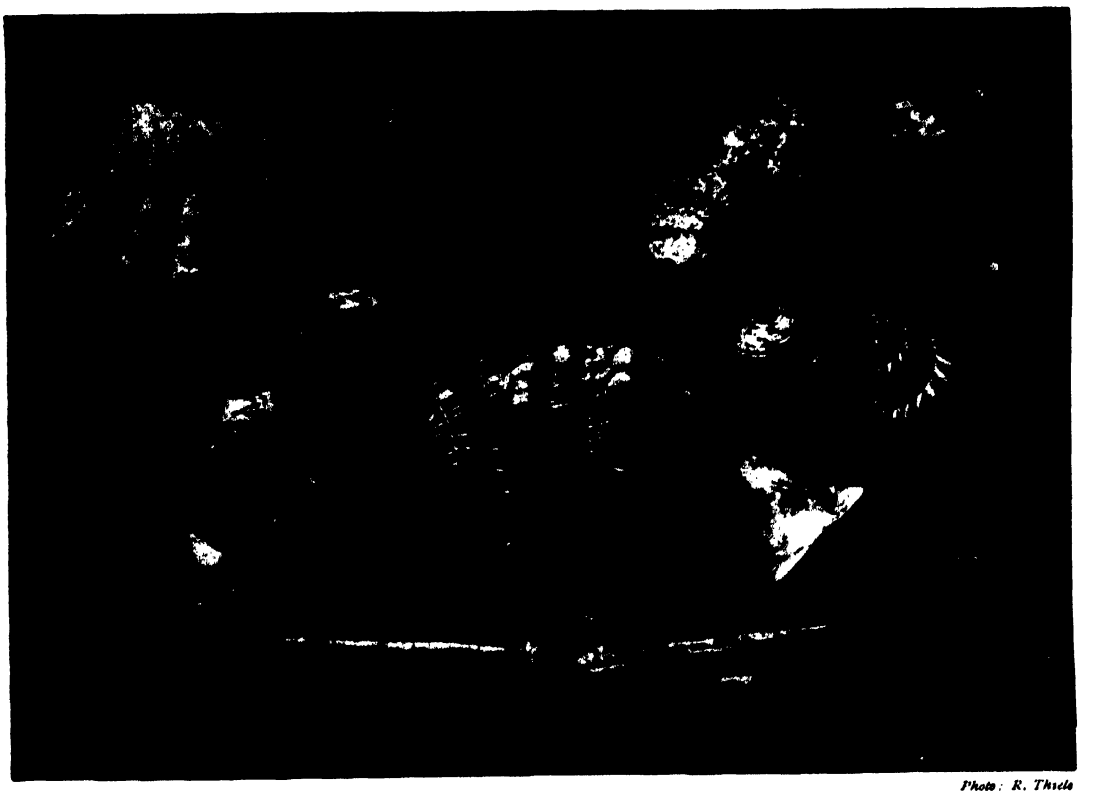


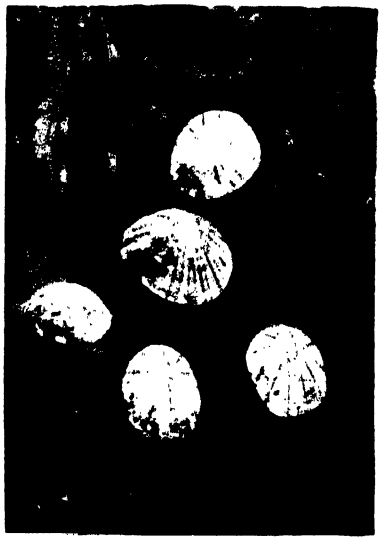
Photo: R. Thiele

Some Beautiful Shells

1. Murex (Venus' comb)
2. Pterocera (Spider shell)
3. Turbinella (Top shell)
4. Harpa (Harp shell)
5. Spondylus (Thorny oyster)
6. Dolium (Tun shell)
7. Hippopus (Horse foot)
8. Voluta (Volute)
9. Voluta (Volute)
10. Conus (Cone)
11. Nerita (Nerite)
12. Nerita (Nerite)
13. Cypræa (Cowry)
14. Nerita (Nerite)
15. Conus (Cone shell)
16. Cassos (Helmet shell)
17. Meleagrina (Pearl oyster)
18. Pecten (Scallop)
19. Solen (Razor shell)
20. Cardium (Cockle)
21. Phasianella (Pheasant shell)

Photo: Stanley C. Johnson

22. Egg Case of the Whelk



Photos: Stanley C.

23. Limpets

Photos: Stanley C. Johnson

24. Butterfly Sigaretus **25. Garden Snail** **26. Carpet Shell** **27. Underside of Limpet**

Photo: Stanley C. Johnson

28. The Tube-building Terebella

Not a mollusc, but a sea-worm—a wonderful builder

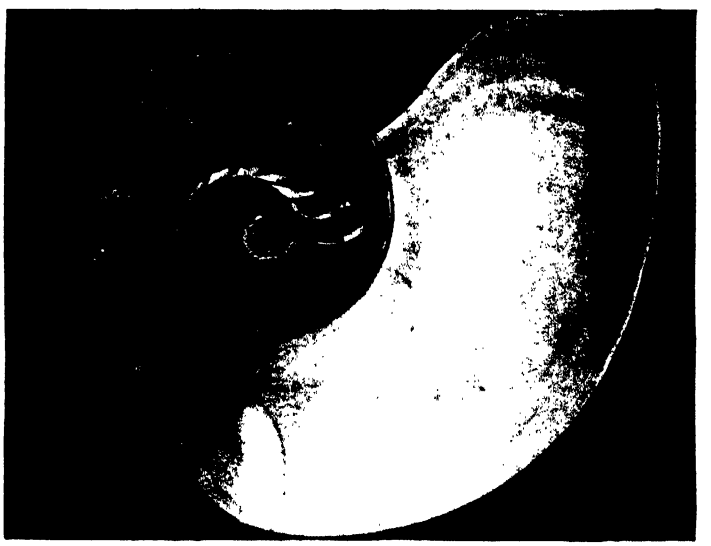


Photo: Harold Bastin

29. Full-grown Nautilus Shell

Cut in half, to show the marvellous chambering of the interior, which enables it to "navigate"

Shell Architecture—II

Most molluscs possess shapes devised specially to provide protection. The common limpet (23) may be cited as a typical example. This ubiquitous little denizen of our sea-coast has a shell that fits tightly down to the rock which it has chosen for a home. When alarmed, the carapace is held in firm contact with the surface of the rock by its sucker-like foot, and most forms of attack are then ineffective. One of the accompanying illustrations (27) shows an underneath view of a limpet clinging to a sheet of glass.

In cases where molluscs are in the habit of adhering to rock surfaces for protracted periods, many shells are provided with holes for breathing purposes, and for the passage of waste supplies.

In the winkle-like Butterfly Sigaretus (24) this aperture lies beside the mouth, but in such a way that the aperture can be used whilst the mouth is closed against attacking foes. In the limpet family the opening varies between a perforated apex and an elongated slit running up the side of the shell from the base. In the ormer, the aperture appears as a line of perforations. In this case, it is interesting to note, first, that fresh holes appear as the animal adds to the shelly matter, and, second, that the earlier holes are generally filled in as new ones come into being.

Certain other photographs which accompany these notes reveal special points of interest.

No. 22 shows the egg case of a whelk. This receptacle contains compartments for hundreds of the young species. It should be noted that only a few shell dwellers are provided with elaborate cases of this nature.

No. 25 shows a common garden snail in motion. Not only does it show the position taken up by the spiral coil whilst its inhabitant is gliding along, but it gives a good view of the mantle, an organ to which we have previously referred.

No. 26 shows a carpet shell, photographed so as to display the elastic ligament which

30. Mussel, attached to Small Stones by Silken Strands

serves as a hinge for the two valves. The ligament, it may be said, has no power to close the shells against an unfriendly intruder; this is the work of a complicated set of muscles contained within the soft body of the mollusc. Hence the shell of a dead bivalve always gapes open although the ligament may be still in good condition.

No. 28 shows a Terebella. This is not a mollusc but a sea-worm. It is of present interest, however, because its tube dwelling is formed by piecing together tiny fragments of broken shells, the cast-off carapaces, in fact, of the interesting creatures discussed in these notes.

Charting the Air

How Science is Combating the Perils of Navigation above the Clouds

By CLAUDE GRAHAME-WHITE

A MAN who puts to sea in a row-boat, when waves are high, may be likened to an airman in a wind. But he on the water has this advantage, he can see the moving forward of waves that threaten him, and bring the bow of his boat to meet them; but the pilot of the aircraft, thrusting his way perhaps through a gale, cannot detect the gusts which may overwhelm him. He is navigating an element that is invisible.

Aerial Danger-Zones

Several thousand men have learned to fly in this uncharted sea. Lives have been lost, it is true; yet, for every accident that has happened, many miles have been flown safely. But aerial danger-zones are a constant menace, the fact that they are unknown adding greatly to their risk. Many disasters that are inexplicable, in the light of our knowledge to-day, may have been due to an eddy or "pocket" which has lurked unseen.

Science, realising these dangers, seeks to provide airmen with data that may protect them. From stations throughout Europe kites are sent aloft which carry with them, sometimes to immense altitudes, apparatus which records any fluctuation in the strength of winds; while from wind-towers, upon which special instruments are placed, a register is kept from hour to hour of the gusts which sweep near the earth.

The aim is to dissect and tabulate the data thus obtained, and prepare a series of air-charts. They should indicate where disturbed areas exist, at what heights they are encountered, and what the maximum force of gusts may be, over a locality known to be dangerous, during varying strengths of wind. In the end, when our airways are traversed by many craft—military and commercial—their commanders will have charts as accurate as those which guide a mariner from sea to sea.

Already, mainly through the experience of pilots when in flight, certain air-pockets and eddies have been localised. There is one marked eddy over the Thames, which evidently follows the course of the river. When an aeroplane passes through it, there is a pronounced rocking and diving, the extent of which is governed by the strength of the wind. Once, carrying a passenger from Hendon to Ranelagh, I had an unpleasant experience in this eddy. My craft, a slow-flying biplane, swayed in an alarming way, and the passenger was much perturbed. But I was never in danger of losing control of the machine, and landed safely.

Air-Pockets

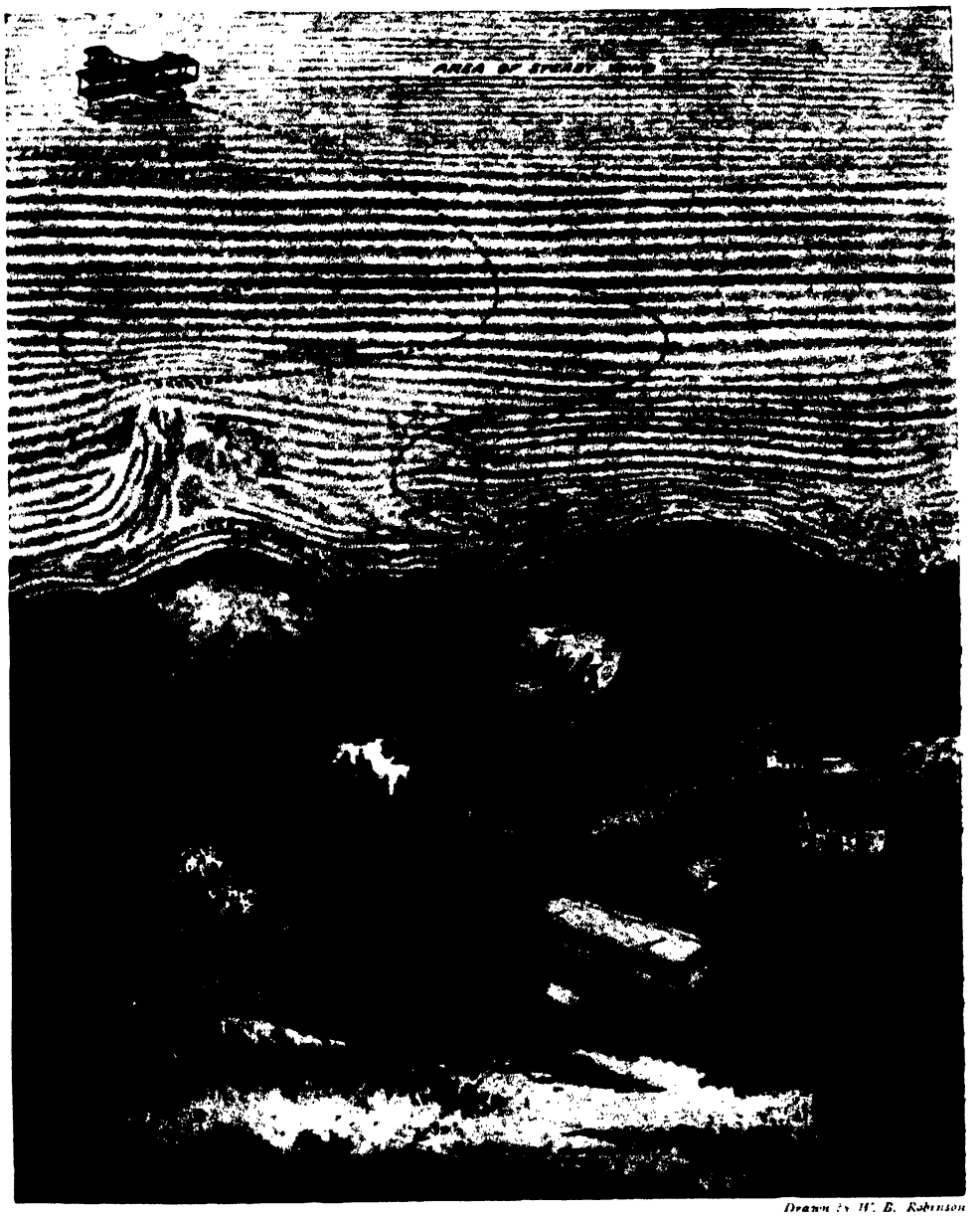
At an English flying school there is a queer and persistent eddy, encountered always above a certain spot, and caused apparently, when the wind is from a certain quarter, by the positions of a wood, a valley, and a hill. No doubt there are numberless other eddies, brought about in similar ways, of the existence of which we are ignorant. In many aeroplane fatalities, a machine has been seen to stand momentarily still in the air, and then fall bow first. A reasonable explanation is that it has flown into an air-pocket, and dived, through a lessening of pressure beneath its planes. If an airman is flying high, in such circumstances, he may regain

The First Lighthouse for Aviators

(Drawn by C. Clark)

In Germany the constant manœuvering by night, in all sorts of weather, of mammoth airships makes the problem of charting the air a peculiarly urgent one. A beginning has been made with lighthouses like the one illustrated, which indicate his whereabouts to the high-flying aviator, just as the ordinary lighthouse does to sailors

command of his craft; but, if he is not, the machine will strike ground before its control-planes have time to become operative. A risk a pilot runs, should his machine pass into an air-pocket, is that its bow may drop so rapidly as to fling him from his seat. In more than one fatality, an airman has been thrown from a machine when it has dived unexpectedly.



Drawn by W. E. Robinson

Eddies, Vortices or Air-Pockets, and other Perils of the Lower Air

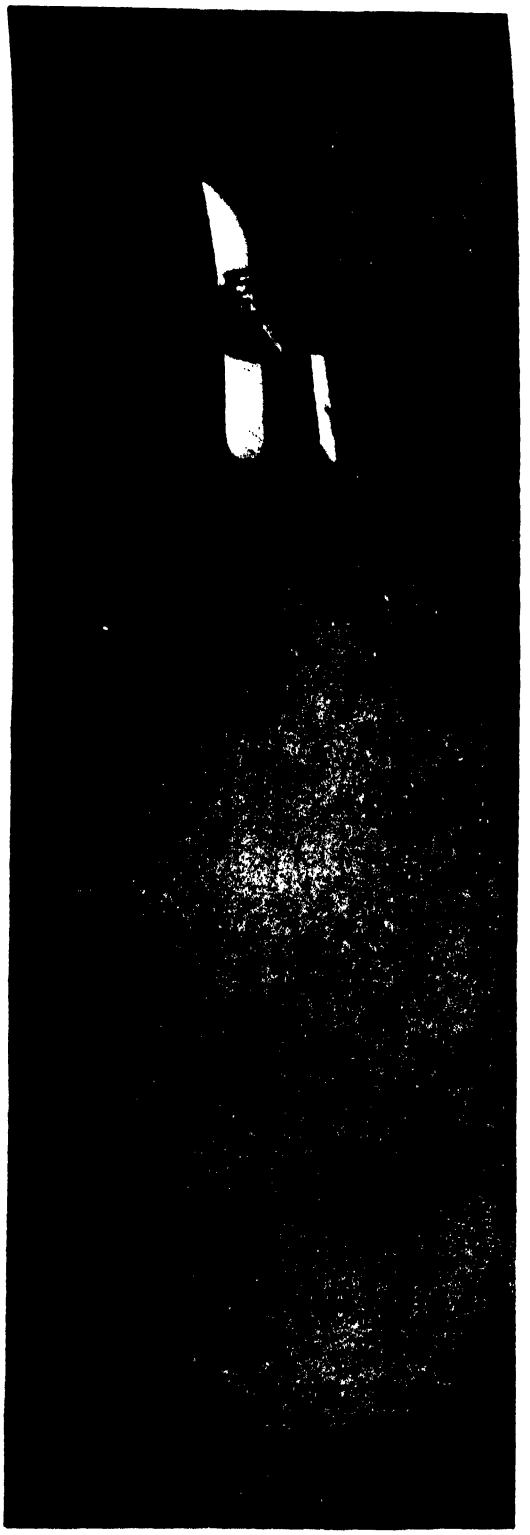
The airman is safest when flying high. Whereas, a few years ago, a pilot was content to pass across country at 1,000 or 1,500 feet, he will now rise 10,000 feet when upon a long flight. It is when beginning or ending a flight that the peril is greatest

In a case not long ago, the pilot was pitched forward from his seat when a machine plunged, but managed to scramble back

again and push forward his elevating-lever, so checking the craft's fall before it struck ground. Broad belts are now worn by many airmen, to prevent their being flung from their machines.

In the eddy at the school I have mentioned, the tendency for a machine that enters it is to drop suddenly, and perhaps side-slip; but the fact that pilots know of its existence is greatly to their advantage. Forewarned, in respect of aerial disturbances, is forearmed, and the safety in which a man may fly, when familiar with the airway he is traversing, shows how valuable air-charts will be. An illustration in point occurs to me. When flying from London towards Manchester, in an endeavour to win the £10,000 prize, I had to pass up the Trent valley, where there is a meeting of winds, and in which the eddies are powerful and dangerous. Upon my first attempt I was ignorant of this danger, and flew at only a moderate height, with the result that the violence of the gusts, coupled with a failing motor, forced me to descend. Paulhan, when he made his flight some days after mine, passed over the valley at a considerable altitude, and so escaped the worst of the eddies. In my pursuit of him, profiting by experience, I also ascended higher, and though the rising of a wind forced me to land, I was making better progress than upon my previous flight.

The moral for the airman is that he should fly high; and it is one he has not ignored. Whereas, a few years ago, a pilot was content to pass across country at 1,000 or 1,500 feet, he will now rise 10,000 feet when upon a long flight. But it is while flying near the ground, when beginning or ending a flight, that he may encounter a dangerous eddy, and be sent crashing to earth. Not long ago, being compelled to attempt a landing through the failure of his engine, a pilot glided over some trees towards an open stretch of land. Near these trees an air-pocket



The Playground of the Upper Air
M. Pégoud engaged in "looping the loop"

A Perilous Dive

(Drawn by S. Bagg)

The illustration shows a typical incident in the everyday life of a British military aviation instructor and one of his pupils. The instructor (sitting in the rear) is in the act of striking his pupil on the helmet to warn him that he is imperilling both their lives and the machine by diving at too steep an angle

lurked. The craft plunged suddenly, went completely out of hand, and was wrecked before the airman could check its fall. The peril in which a pilot may find himself when low over trees, particularly if these crown a hill, with the land sloping downwards below them, has been indicated by other mishaps. In such circumstances, if there is a wind, a powerful air-wave sweeps above the trees, and curls over them towards the ground. An aircraft, should it be caught in such a wave, is sucked down with it, and refuses to respond to its controls.

But science is taking steps towards the charting of the air, and much has been determined that is of value. It is recognised that the air does not sweep smoothly across the land. Experiments have shown that, on a day when the wind has every appearance of being steady, definite disturbances may be noted, while eddies and gusts are formed constantly in that stratum of air which is affected by passage above obstructions on the land. Importance is attached, from the aviator's point of view, to tests made to determine how the speed of a gust may vary, even at points which are close together. By duplicate recording apparatus, placed upon wind-towers only 40 feet apart, it has been found that a gust of 30 miles an hour may strike one registering plate, while the pressure upon the other, at the same moment, is not more than 15 miles an hour. To a pilot flying a passenger biplane, in which the wing-span exceeds 40 feet, such data is significant. It means that, should he be flying on a boisterous day, he may be struck by a heavy gust beneath one wing-tip while, under the other, the thrust remains little more than normal. The tendency, in such a case, is for the machine to lurch, and if this is not checked promptly it may develop into a side-slip, and send the machine reeling towards the ground.

Side-slips are the airman's dread. To appreciate their menace, one should imagine a machine in flight on a windy day. As gusts sweep upon it, the craft rolls from side to side. To prevent this motion becoming dangerous, the pilot is provided with a lever and operating wires, which actuate balancing planes, or ailerons, fitted at the rear extremities of his main-planes. When a gust assails him, he depresses the ailerons upon the side of his machine that is tilted down, and this action—having a dual effect—draws up the ailerons upon the opposite plane-ends. The result is to give an additional "lift" to the wings upon which the ailerons are depressed, and to exercise a thrust downwards upon those which have their ailerons raised. Responding to this influence, the aircraft should resume an even keel. Such mechanism is effective under normal circumstances; but occasionally the pressure of a

A Fearful Fall

The photo shows a British military aeroplane which has met with disaster, while volplaning from a height of only 300 feet, when on its way to be delivered to the War Office authorities at

gust becomes abnormal. Then, insensitive to its balancing planes, an aircraft heels until its wings stand almost vertical. Ceasing to move forward, it hovers thus, then begins a sideway fall.

An Awkward Predicament

This was the predicament of one airman I know: when high above a village, on a cross-country flight, his biplane was struck by a gust and side-slipped helplessly. In such plight, a pilot might appear doomed; so, in this case, he would have been, had he not been flying high. As it was, he did not lose presence of mind, and, by doing promptly the only thing possible, was able to avert disaster. When he found his machine side-slipping, he thrust forward the lever operating his elevating-planes, and accelerated his motor to its full power. So long as his craft fell sideways, he knew he was helpless to check it. What he strove to do was to convert this side-slip into a forward dive, and enable his controlling-planes to grip the air. His aim was to induce the machine to fall forward at a speed greater than it was slipping sideways. At such a crisis, if nerve and experience stand him in good stead, the pilot can change his side-slip to an almost vertical dive; then, as he plunges towards the ground, he will find his elevating-planes effective, and will be able to restore his craft to its normal flight. But, if he is not at a considerable altitude when beginning this manœuvre, the pilot will be in grave peril. In the case of the airman cited, the biplane fell 800 feet before he could regain control. Had he been flying low, he would have been killed.

Strange escapes are chronicled of men whose craft, struck by abnormal gusts, have gone beyond control. One English military pilot, overtaken by a rush of wind that preceded a storm, had his biplane turned completely over; and, failing to restore its equilibrium, he fell 1,500 feet into a field. But the planes of the machine acted as parachutes, and it fluttered down so lightly that the airman, springing clear before it touched ground, escaped with nothing worse than bruises. In France, the monoplane of a military pilot turned on its back in a wind, flew in this manner for some distance, then righted itself automatically, and gave experts a first suggestion of the feasibility of upside-down flying. What M. Pégoud has since demonstrated is this: if a man be high enough, and in a stable machine, he can restore it to a normal position, no matter how it may be thrown about by the wind. But, at considerable heights, the wind is usually steady; it is when nearing the earth, say at the end of his flight, that an aviator dreads unknown waves and eddies.

One may liken an aeroplane near the ground to a boat just launched upon the sea; when the swell is heavy, it may be swamped by a wave before it is clear of the shore. So it is with an aircraft: on a gusty day, until some distance from the ground, a machine will rock and sway. Then, as he ascends higher, a pilot finds the upper layers of air less disturbed, though the wind may still be strong. Once free from land currents, the airman who has an amply-engined machine may weather a 50-mile-an-hour wind. It is not its strength, so much as its eddies and gusts, that prove the menace when flying in wind.

The March of Science

But perils of the air are yielding already to the march of science. We have excellent maps for use in flight, which show us prominent landmarks and the situation of landing-grounds; and in France these maps indicate dangers for a pilot descending, such as the presence of telegraph wires, for instance.

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